POWER PLANT ENGINEERING

Established Over 33 Years

VOL. XXXIII CHICAGO, MAY 1, 1929 No. 9

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Published on the 1st and 15th of each Month by the

Technical Publishing Co., 53 West Jackson Blvd., Chicago

New York Office, 171 Madison Avenue

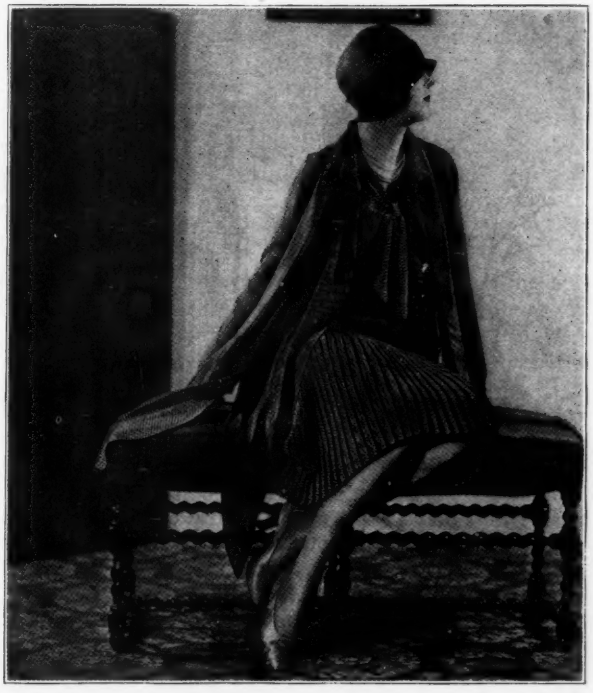
Subscription price $2.00 a year in the United States and possessions. Canada $2.75 a year. Other countries $3.50 a year. Single copies 15 cents.

Copyright 1929, by Technical Publishing Co.

Entered as second class matter May 1, 1908, at the Post Office at Chicago, Illinois, under the act of March 3, 1879.

Member, Associated Business Papers, Audit Bureau of Circulations.

Circulation of this issue 23,850



Models

THERE BE THEM as approves of models and there be them as don't. Generally, them as don't lack the imagination and ability to look ahead a wee bit and see the real thing.

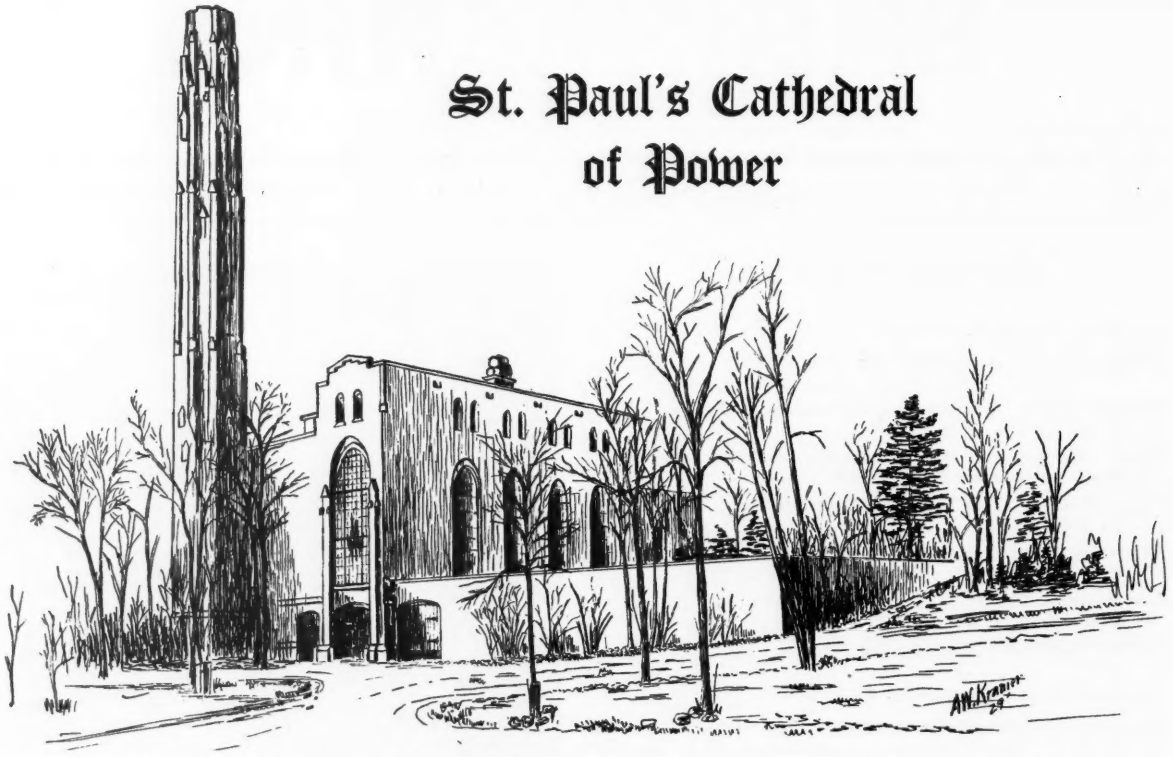
Engineers like models and some are willing to admit it in confidence, of course, but not many of them play around openly with models as hydraulic engineers do.

Professional reasons lie back of this—electrical engineers, intellectual, dark, good-looking fellows, are grabbed off young and married by the good-looking girls; power plant engineers, dirty, grubby, drab and nondescript in their professional uniform, overalls, have no S.A. while hydraulic engineers, busy harnessing the forces of nature, are dashing and romantic but being wild and untamed they manage to escape entangling alliances and remain free to pursue their inclinations.

Now it is peculiar that of all nationalities, the Germans like models best. Of course the French, Italians, Russians, Swiss, Scandinavians, Americans and even the English have a fling at them occasionally but they seem to lack the professional technique of the Germans.

In fact, Mr. Van Leer thinks models are an important feature of engineering. From his remarks on page 539, it seems that the Germans build models of everything: model dams, model turbine runners and model draft tubes by the dozen.

St. Paul's Cathedral of Power



ENGINEER AND ARCHITECT COMBINE TO MAKE THIS GOTHIC POWER PLANT WITH THREE 300-HP. BOILERS AND TWO 150-KV-A. GENERATORS RIVAL THE REPUTATION OF THE SCHOOL

SAINT PAUL'S SCHOOL, for 70 yr. a power in the educational development of our country, was founded April 3, 1856, at Concord, New Hampshire, by George C. Shattuck, M. D., with Rev. Henry A. Coit as the first rector and with three boys as students.

From this modest beginning, the school has grown to the present enrollment of over 400 boys ranging in age from 14 to 18 yr. and to a position second to none in the list of college preparatory schools. Doctor Samuel S. Drury, the fourth and present rector, has held this office since 1910.

Built in 1906, the old power plant was hand fired. The new power plant, made possible by gifts to the school, is modern in design and equipment with the added distinction of forming a beautiful addition to the group of school buildings. Of Gothic architecture, the power plant itself is distinctive among power plants while the Gothic stack is ranked among the most beautiful chimney designs in the country. The entire plant is a

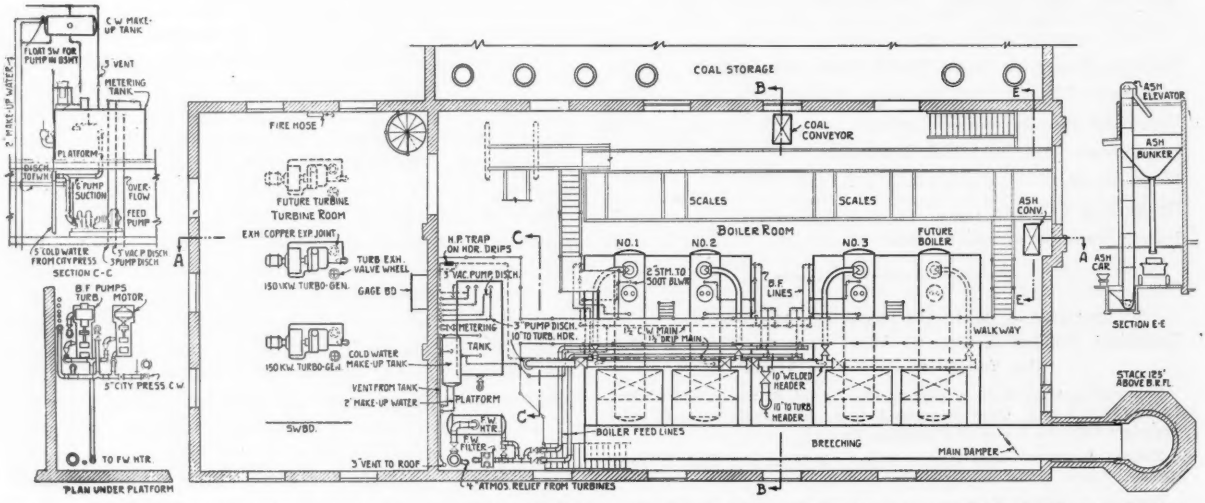


FIG. 1. OPERATING FLOOR PLAN OF ST. PAUL'S SCHOOL POWER PLANT. SECTION AA IS SHOWN IN FIG. 7 AND SECTION BB IN FIG. 4

fine example of coöperation between engineer and architect to make the plant both efficient and beautiful.

In Fig. 1, is shown the plan of the plant including the enclosed coal storage. Three Heine 150-lb. gage, 300-hp., 48-in. dia. longitudinal drum boilers with tubes 18 ft. long and fired by Westinghouse single retort side dump stokers, designed for a maximum of 250 per cent of boiler rating, are installed. At the far end of the boiler room, Fig. 6, space is provided for a fourth boiler unit, which will be installed when the steam demand is sufficient.

Plant Can Supply Power to, or Purchase from, the Public Utility System

Electric power is supplied by two Westinghouse 150-kv-a., 2300-v., 3-phase, 60-cycle noncondensing turbine driven generators shown in Fig. 5. Space is provided and building designed for future third unit. Electric power distribution and switching are handled by a five-panel switchboard while a complete gage board located adjacent to the turbine room partition between the two turbines gives the engineer on watch complete data regarding the entire system. Connection is made with the local public utility system so as to take or supply power as desired.

Coal from the overhead bunkers is weighed by individual automatic Richardson coal scales before delivery to the stoker hoppers. Each boiler is equipped with a Coppus forced draft turbine blower, a Reliance water column, Ashton safety valves, Jenkins nonreturn valves, Lunkenheimer blowoff valves, Bayer soot blowers, Enco balanced draft system, Hays CO_2 recorders and three

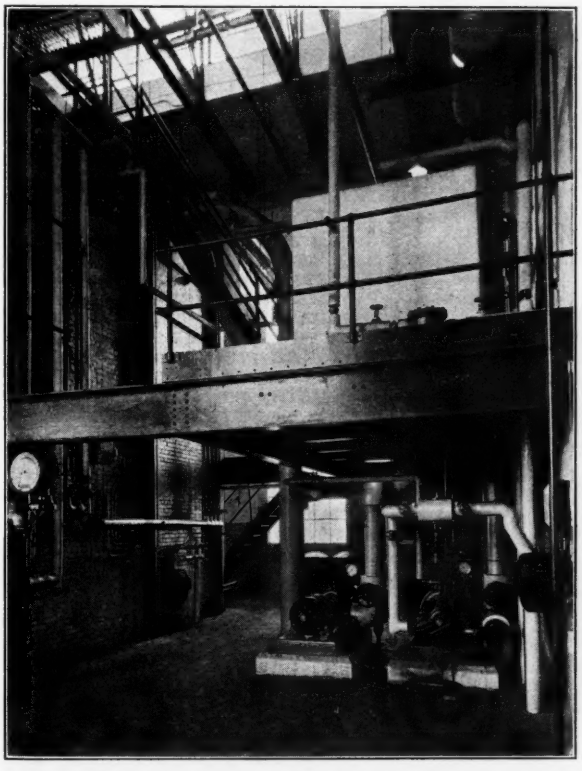


FIG. 2. BOILER FEED PUMPS, ONE MOTOR AND ONE TURBINE DRIVEN, ARE INSTALLED UNDER THE STORAGE HOTWELL

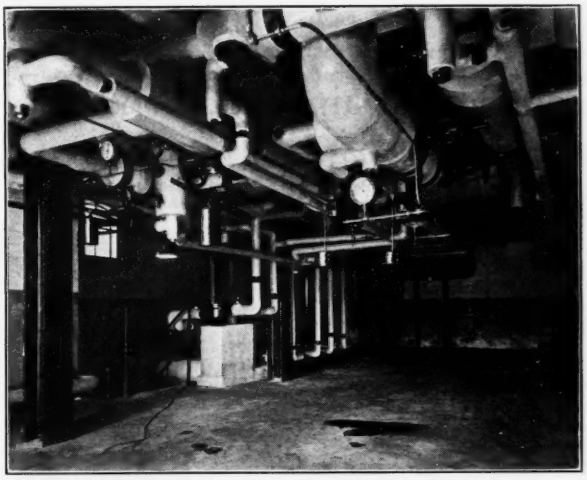


FIG. 3. ALL PIPING IS LOCATED UNDER THE OPERATING FLOOR

pointer draft gages, Bailey indicating, integrating and recording steam flow meter and Mason regulator on forced draft turbine throttle operated by a Ruggles-Klingemann damper regulator under control of the steam pressure.

One of the interesting features of the installation are the cast-iron wind boxes for the stokers, as shown in the cross section of the boiler, Fig. 4. These cast-iron sections are held in place by steel supports. The boilers are horizontally baffled and the bottom of the front header is set 12 ft. above the boiler room floor or about 9 ft. above the grates. The furnaces are 7 ft. 11 in. wide and 16 ft. 1 in. long.

River Water Used for Boiler Make-Up

Boilers are connected to the stack by a breeching of No. 10 iron measuring 4 ft. 6 in. by 8 ft. The brick stack is octagonal, 7 ft. in dia. inside at the ground and extending 125 ft. above the boiler room floor.

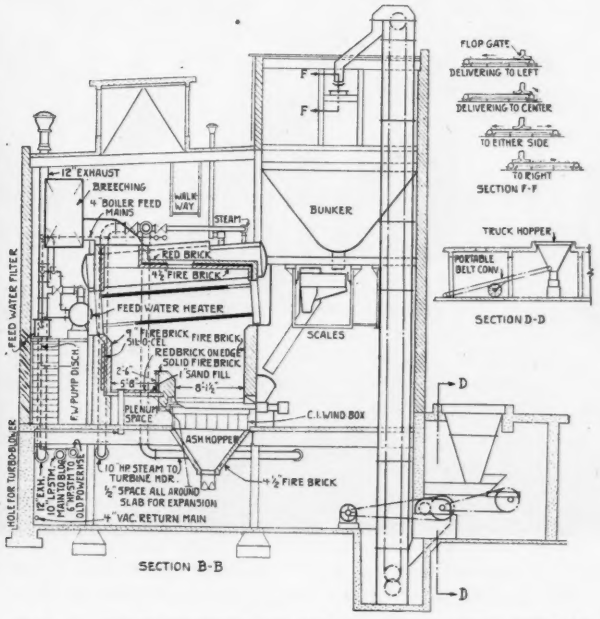


FIG. 4. CROSS SECTION OF THE BOILER ROOM. THIS IS SECTION BB OF FIG. 1

Complete Equipment, Good Arrangement and Beauty of Structure Are Appropriately Unified At St. Paul's

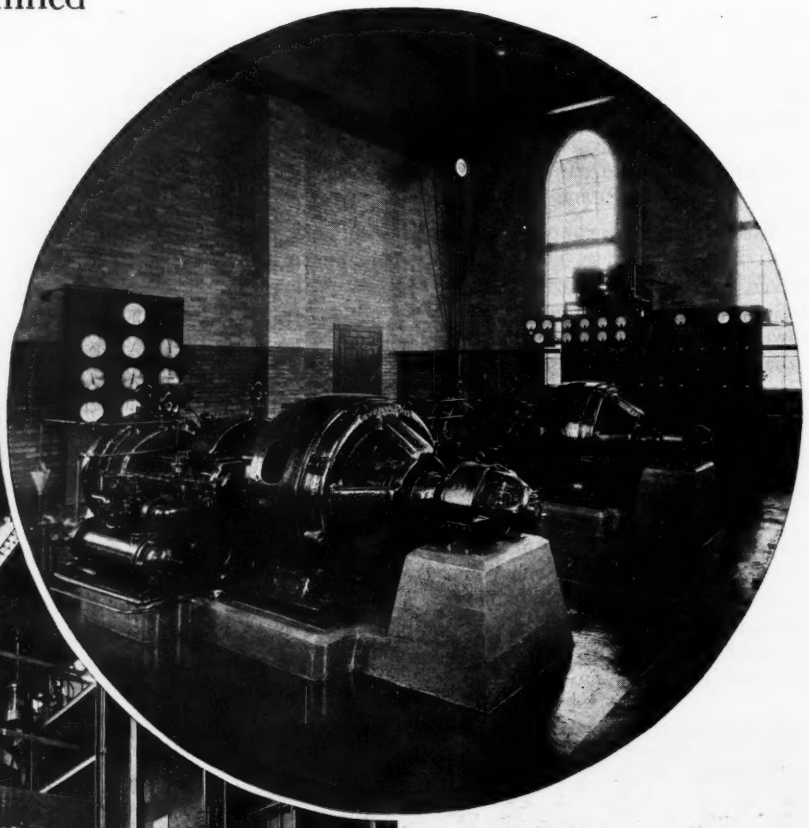


FIG. 5. GOTHIC WINDOWS ADD TO THE PLEASING EFFECT OF THE ATTRACTIVE TURBINE ROOM WITH ITS TWO 150 KV-A. NON-CONDENSING UNITS. THESE SUPPLY POWER AND EXHAUST STEAM TO THE SCHOOL BUILDINGS

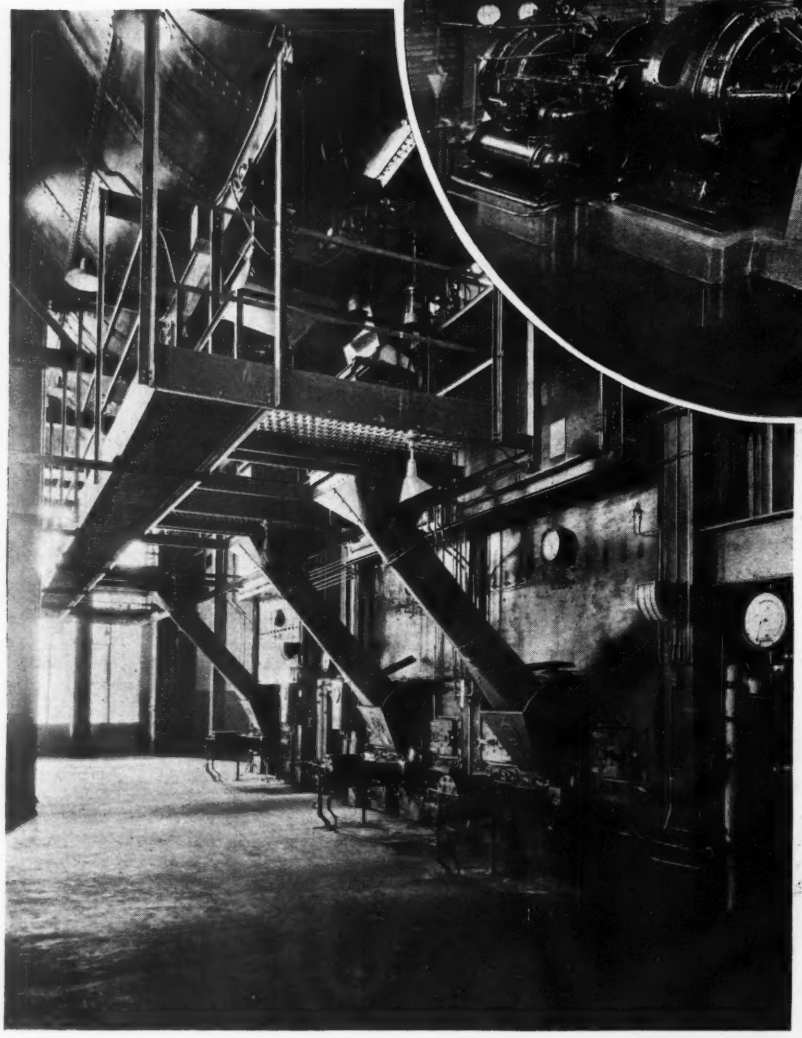


FIG. 6. INSTRUMENTS, WELL LIGHTED AND ARRANGED SO AS TO BE OF MAXIMUM SERVICE TO THE FIREMAN, ARE A FEATURE OF THE BOILER ROOM. THIS CONTAINS THREE 300-HP. STOKER-FIRED BOILERS, WITH SPACE LEFT FOR A FOURTH FUTURE UNIT. COAL FED FROM OVERHEAD BUNKER TO STOKERS IS MEASURED BY INDIVIDUAL AUTOMATIC COAL SCALES. COMBUSTION CONTROL SYSTEM AND REGULATORS AID IN SECURING GOOD BOILER OPERATION

The plant is located on the bank of the Turkey River which flows through the campus and river water treated with soda ash is used for feedwater make-up. The make-up water pump is a float controlled Jennings-Hytor self-priming centrifugal driven by a 5-hp. motor. This pump takes its suction from a well through an Andale duplex strainer and discharges into a 30 in. dia. by 72 in. long overhead cold water tank shown in section CC, Fig. 1.

Make-up from this tank controlled by a float-valve flows by gravity to the 6 ft. by 12 ft. by 6½ ft. high Webster V-notch metering storage tank with a capacity of 1800 gal. storage below the low water mark. The tank is constructed of ½-in. wrought iron with welded joints throughout. From this storage hotwell the feed-water flows to the feed pumps below and is pumped through a Ross closed feedwater heater to the boilers.

Two 2-in., 1750-r.p.m., 5-stage Dayton-Dowd feed pumps, Fig. 2, are installed. One is driven by a 30-hp. Westinghouse motor and the other by a 30-hp. Westinghouse steam turbine. The relative location of the heaters, tanks, meter and pumps is shown in the plan, Fig. 1, section CC, Fig. 1 and section AA, Fig. 7. The Ross steel tube heater when used with 2 to 5 lb. steam pressure from the turbine exhaust is designed to heat 54,000 lb. of water per hr. from 100 to 205 deg. F.

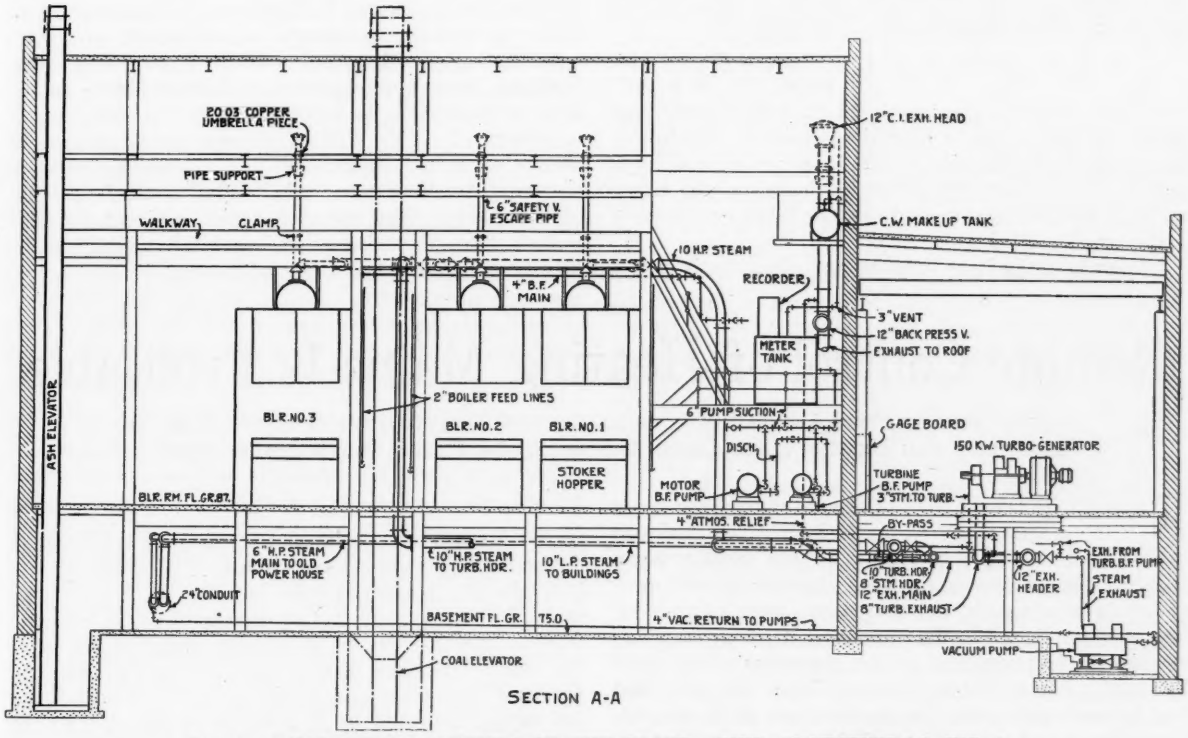


FIG. 7. LONGITUDINAL SECTION OF THE PLANT. THIS IS SECTION AA, FIG. 1

Two 2-in., 1750-r.p.m., 5-stage Dayton-Dowd feed pumps, Fig. 2, are installed. One is driven by a 30-hp. Westinghouse motor and the other by a 30-hp. Westinghouse steam turbine. The relative location of the heaters, tanks, meter and pumps is shown in the plan, Fig. 1, section CC, Fig. 1 and section AA, Fig. 7. The Ross steel tube heater when used with 2 to 5 lb. steam pressure from the turbine exhaust is designed to heat 54,000 lb. of water per hr. from 100 to 205 deg. F.

Entire Campus Heated from New Plant

The steam distribution piping is so designed that it will eventually form a complete loop of the campus with steam to be supplied from the new power house to both ends of the loop. This method insures against interrupted service. At present, high-pressure steam is supplied as far as the site of the old power house, the latter having been demolished after the new plant was put in operation. Connections are made at that point to present lines to buildings formerly supplied from the old power plant. Leaving the new power house is a 6-in., 60-lb. line extending to a distribution chamber on the site of the old power house; a 10-in. low-pressure main to the buildings, a 3-in. high-pressure return line and a 4-in. vacuum return from the buildings.

On the steam piping and return system are installed Templeton Bros. return traps, Johns-Manville high and low-pressure traps, Foxboro gages, Jenkins gate, globe and non-return valves, Mason high-pressure reducing valves, Davis back pressure valves, Ross expansion joints, Atwood and Morrill atmospheric turbine relief valves and Crane steam separators, escape pipe and safety valve mufflers. An Andale duplex oil filter is installed on the boiler feed line. Compressed air is supplied for blowing motor windings by a Lindsay 4½-c.f.m. portable compressor driven by a ½-hp. motor.

For vacuum service, two Jennings-Hytor Size E pumps, one driven by a 7½-hp. motor and the other by a 7½-hp. turbine, are used with space allowed for an additional turbine unit. All high and low-pressure traps, vacuum pumps and return pumps discharge to the metering tank on the balcony. City water is used on the turbine glands and this is discharged to the cold water make-up tank.

1500-T. Inside Coal Storage Provided

One of the interesting features of the plant is the large inside coal storage. This covered storage 80 ft. square and 15 ft. deep, shown on the plan, holds 1500 t. It is enclosed by the brick wall shown in the headpiece which forms part of the power plant building. Due to

the typography, the storage is inconspicuous, as the reinforced roof serves as a receiving yard upon which coal trucks may be driven. All of the coal and ash handling equipment was supplied by Stephens-Adamson Mfg. Co.

When coal is to be used immediately, the truck is dumped into a steel receiver hopper approximately 7 by 10 ft. and 8 ft. deep which is normally covered by a swinging cover. This arrangement is shown by section BB, Fig. 4. A reciprocating steel plate feeder draws the coal from the hopper and feeds it to a 24 by 20-in., 25-t. per hr. double roll crusher driven by a 15-hp., 600-r.p.m. motor. From the crusher the coal is elevated by a bucket elevator with 67 ft. centers made of 14 by 7 in. steel buckets bolted to parallel chains. This elevator is driven at a speed of 100 ft. per min. by a 10-hp. motor and discharges through a two way chute to the shuttle conveyor shown in section FF, Fig. 4.

This shuttle conveyor, half the length of the coal bunker, distributes coal to any point. It is a self-contained 16-in. belt conveyor 21 ft. long mounted on wheels so that it can be shifted as desired. The belt is driven in either direction at 200 ft. per min. by a 5-hp. motor. The bunker, extending the length of the boiler room, is divided into two sections, one 300-t. coal bunker and a smaller ash hopper at the end.

Arrangement of the bunkers and elevators is shown in section AA Fig. 7 and cross section of the ash elevator by section EE of Fig. 1. Ash is drawn from the ash hoppers of the boilers to 21-cu. ft. side dump ash cars which are pushed to the end of the building and dumped into the ash elevator hopper. This elevator is built on 65-ft. centers and has 10 by 6-in. malleable iron buckets driven at 200 ft. per min. by a 5-hp. motor. The rated capacity is 10 t. per hr. Ash is taken from the power plant by truck.

If coal is to be stored, it is dumped at the desired location through a network of coal holes in the roof. This coal can be reclaimed quickly by means of two 18-in. by 30-ft. portable belt conveyors arranged to discharge into the coal crusher, as shown in the section DD, Fig. 4.

The architectural treatment of the plant and stack was handled by Charles Z. Klauder of Philadelphia, Pa., while the building construction, mechanical and electrical design were handled by Hollis French and Allen Hubbard, consulting engineers of Boston, Mass. In the latter organization, the building construction design was in charge of J. F. Wilbur, the mechanical design in charge of F. A. Merrill and the electrical design in charge of W. V. Batson. E. Randall is chief engineer of the plant. The splendid result achieved by this united effort of engineers and architect might well be called "St. Paul's Cathedral of Power."

Remote Control of Heating Mains Is Profitable

Utility Company Finds Accurate Electrical Control Apparatus for Operating Reducing Valves in Steam Heating Mains Improves Service. By Fred S. Beach[1] and F. M. Lewis[2]

EXACTING DEMANDS of remote control for steam heat pressure mains were met by a system designed by the engineering department of the Northwestern Electric Co. of Portland, Ore. Insofar as standard materials were usable, the component parts of the system were purchased in the open market. The actuating mechanism, however, was not an apparatus which could be bought, nor could anything available that we could buy be made to answer the requirements of the operating cycle; hence the services of the engineering department were requisitioned to devise an operating unit as well as to provide a suitable circuit.

Conditions set forth by the steam heat department through its superintendent, A. D. Leach, were: that it must be an electrically operated device; the control should be in the office of the company or in the building wherein the offices of the company were located; an operating period of a sufficient length of time should be provided to make raising and lowering pressures a deliberate and accurate procedure; an indicating instrument located in the office having a dial calibrated in terms of turns of an adjusting nut on the pilot valve, which graduates pressure on the diaphragm of the main regulator valve in the steam main, was essential, while the system of requisite relays and principal electrical apparatus and driving and timing mechanism, as well as the pilot control valve, were to be located at the reducing station manhole, the distance between control point and reducing station being slightly over one mile.

With conditions outlined, the first procedure was to devise the following control circuit. The electrical control circuit diagram, shown in Fig. 1, is a simple multiple wire control for operating the two reducing valves. Eight wires of a 5800-ft. underground cable are used. This cable is also used for pressure and temperature indicators and remote operated de-calorizing jet valves, indicated by 1, 2 and 3 in Fig. 2. At the control stations, the number of turns which the pilot valve is open is at all times indicated on the position indicator shown at the right of the small panel in Fig. 3. The operator can open or close the pilot valve at will, always knowing the exact position of the pilot valve.

Each reducing valve is equipped with its own operating motor, which operates its pilot valve and a position indicator controller. These motors are controlled through one magnetic reversing switch which, in turn, is operated by a "raise" and a "lower" auxiliary relay. An eight-pole double throw knife switch located in the smaller manhole at the reducing station is used to select which pilot valve is to be connected to the control station. The changing of this eight-pole switch connects the control wires to the auxiliary relays, changes the indicating lamps shown below the position indicator in Fig. 3 at the control station, showing which valve is to be controlled, connects the proper operating motor to the reversing switch and connects the proper position indicator controller to the position indicator.

[1]Chief Draftsman, Engineering Dept., and [2]Assistant Elec. Eng., Northwestern Elec. Co., Portland, Ore.

Mounted on the same panel with the position indicator and lamps at the control station is the control switch, which is a single-pole, double-throw rotary type control switch, the handle of which shows below the two indicating lamps and the position indicator. When the control switch is turned to the right, the "lower" auxiliary relay at the reducing station is energized. This in turn energizes the "lower" coil on the magnetic reversing switch and the operating motor, through reduction gears, turns the pilot valve in the "lower" direction, thereby reducing the steam pressure. Likewise, by turning the control switch to the left the "raise" auxiliary relay is energized. This energizes the "raise" coil on the magnetic reversing switch and the operating motor is reversed and the pressure is increased.

Attached to this mechanism is the position indicator controller which revolves approximately 285 deg. from full closed to full open of the pilot valve. This controller is electrically connected to the position indicator. The number of turns which the pilot valve is open is always indicated at the control station by the pointer on the position indicator scale calibrated in "turns on pilot valve."

Provisions have been made for controlling the eight-pole knife switch electrically from the control station if the manual operation does not prove satisfactory. This will give complete remote control of the reducing station and make it unnecessary for an attendant to go to the reducing station to change the control from the high to the low-pressure valve.

Details of Valve-Operating Mechanism

Mechanical features involved are described in detail as follows and in Fig. 4 is shown the installation at the reducing station. Two manholes are used; the smaller of the two houses the electrical apparatus and motor driving mechanism shown in Figs. 5A and 5B, while the larger houses the pilot valve, shown in Fig. 2, which has been rebuilt, as shown in Fig. 5C, to make it suitable for operation by electric motor drive. The gear train on this reconstructed pilot valve has a compound ratio of 28.8 to 1 which advances or withdraws the graduating nut one thread for each 28.8 turns of the sprocket driving it. The driving sprocket is one having 23 teeth and is driven by a 12 tooth sprocket on the line shaft which extends from the small manhole to a point in the main manhole where the chain drive which includes the two sprockets noted above is located. .

This small ratio in the chain drive increases the ratio to 55.2 to 1. The line shaft is driven through a 1 to 1

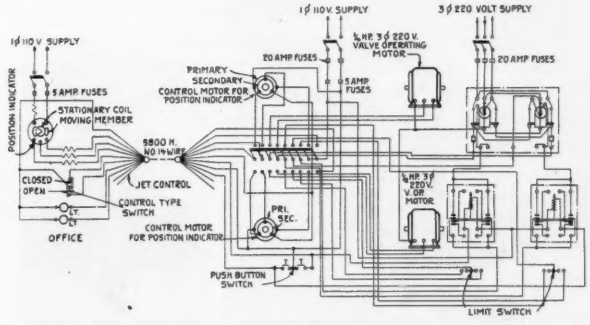


FIG. 1. CONNECTION DIAGRAM FOR THE REMOTE CONTROL MECHANISM FOR HIGH PRESSURE STEAM MAINS

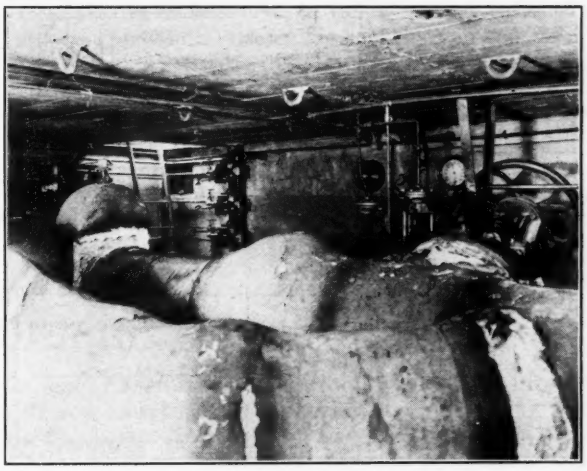


FIG. 2. A VIEW OF THE LARGER MANHOLE

ratio chain drive on the motor mechanism coming from a reduced motion shaft having a ratio of 36 to 1 between it and the driving motor which, when compounded with the 55.2 to 1 ratio, makes a total final ratio of 1987.2 to 1. The drive motor has a full load speed of 1725 r.p.m. so that to turn the nut up or down requires more than one minute to accomplish; 69.12 sec. to be exact. Approximately 11 turns or 11/12 in. travel on this graduating nut are required to cover the entire range between zero and maximum regulated pressure. It will be noted in Fig. 5C the 48-tooth gear mounted on the nut is driven by a pinion of an extremely wide face, this width being required to allow for the up and down travel of the nut with its driving gear. With the exception of the wide-faced pinion, all of the gears in this assembly are what is known as stock gears and were purchased ready to use from the gear makers' Pacific Coast stock at San Francisco.

The position indicator controller is the small motor in the foreground of Fig. 5B. The relative motion is based on a compound ratio of 28,800 to 1. Immediately back of the controller are seen two cams and a disk with lever attached which has a hand knob, the purpose of which is to vary the setting of this lever in relation

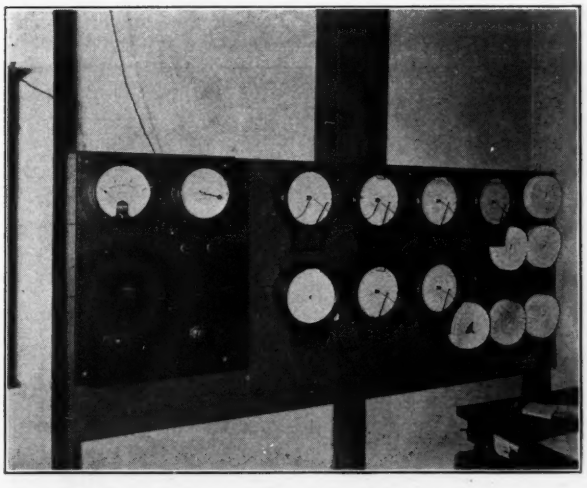


FIG. 3. CONTROL STATION SHOWING GAGES AND INDICATORS

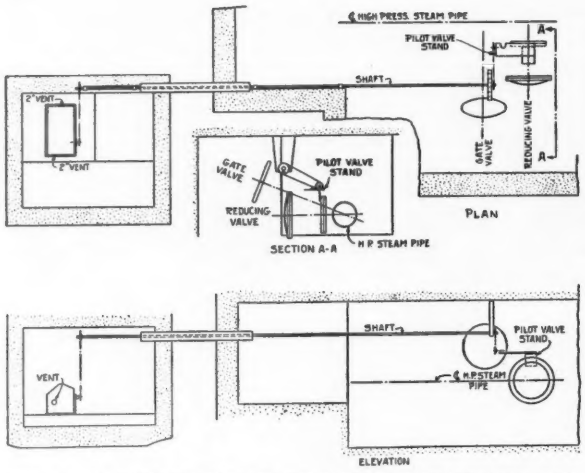


FIG. 4. ARRANGEMENT OF THE REDUCING VALVES AND OPERATING MECHANISM IN THE MANHOLES

to the disk by a clamp on the rim of the disk which is clearly shown. At the lever end a sleeve is noted around clamp screw shank. Assuming that the disk is traveling toward the right of the figure, the arm, being clamped thereto, travels also to the right with it until the sleeve around the clamp screw strikes the prong on the lower side of the right-hand cam.

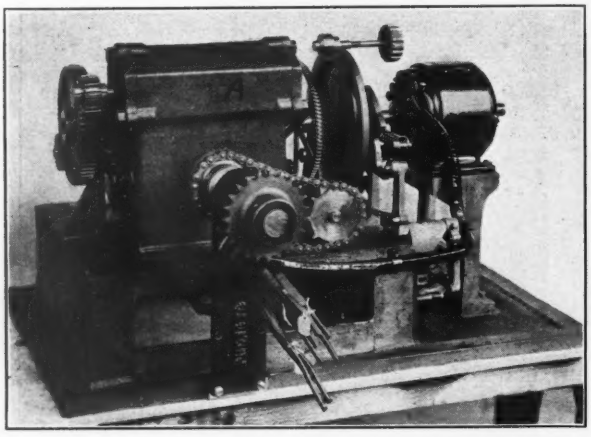
This causes the cam to tip to the right until the heavy spring (the end of which may be seen at the right of, and just behind the controller) is stretched to the high point of the crankpin arc of the crankpin to which it is attached and carried over this center until the energy stored in the spring in stretching overbalances after the center of motion of lever is passed and snaps the cam hard over. This causes the lobe on the cam to strike the roller on the end of the small lever at the extreme right of the controller, swinging this lever outward, turning the shaft on which is mounted a similar lever that extends downward bringing it into quick contact with the button on the end of a rod which actuates a limit switch. The limit switch is visible behind the stand on which the controller is mounted. In thus breaking the limit switch contact, the motor is stopped from further travel to the right, and to operate in the opposite direction it must be energized by manual means through the control switch at the control station. When reversed, the arm, traveling with the disk, re-arms the limit switch trip cam and until this cam is so re-armed, travel to the right is not possible.

The cam at the left is similar and acts similarly to cause stoppage in left-hand rotation. Referring to Fig. 5A, the principal elements of the gearing, and the left-hand limit switch trip cam and lever may be seen. The drive motor is geared to its first reduction through the pinions and idler shown. These are stock gears from the same stock as those on the valve. The 36 to 1 first reduction, however, is a special worm gear reduction made locally. The timing mechanism derives its motion from the small 1 to 1 chain drive shown. The large sprocket in the foreground is for the first chain drive for pilot valve operation. The driven sprocket in the small chain drive turns a shaft carrying a small single thread worm meshing with the worm wheel that can be seen to the right of the first reduction housing.

Watertight Casing Used to Protect Against Manhole Floods

This worm drive reduces motion in the ratio of 100 to 1, making a compound ratio of 3600 to 1 at this point which is increased to a ratio of 28,800 to 1 by means of a 12-tooth pinion keyed on worm wheel shaft meshing with the 96-tooth internal spur gear through a 42-tooth idler. The internal spur gear is attached to the trip arm drive disk and the object of the 42-tooth idler is to make the axes of drive disk and 100 tooth worm wheel coincident and the design more symmetrical. The worm wheel is keyed to axis shaft and disk runs loose thereon. The disk hub is extended to provide a bearing for the trip arm hub and affords a coupling for the shaft of position indicator controller as it has the same motion relative to driving motor as the disk and as noted in the beginning of this article. The assembly shown in Figs. 5A and 5B is provided with a water tight cast-iron casing which seats on a gasket on top of the machined extended base flange.

By a gland type packing around it, the main drive



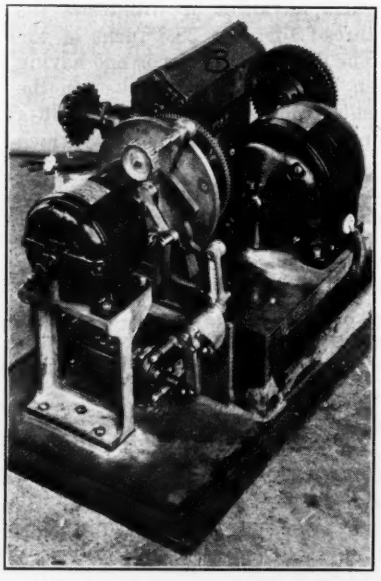


FIG. 5. DETAILS OF THE CONTROL, DRIVING MOTOR AND PILOT VALVE

shaft is made water tight. A water tight conduit fitting is also provided directly beneath shaft and sprocket where cable leads are seen. The object in providing a water tight housing is to protect the machine against manhole floods which sometimes occur during heavy rains. Vents are provided in the casing to take care of motor ventilation. These vents are piped above the high water point of any flood which might occur.

While the apparatus and its installation were accomplished under considerable expense, the saving derived from making it unnecessary for a man to travel the mile and one tenth between the headquarters and reducing station will repay the company by giving a more flexible means of pressure and temperature control. It is well to state in conclusion that the foregoing was not a hypothetical assumption, as the idea had been tried out with a more primitive mechanism which has been, and still is, in use. All of the shortcomings of the earlier mechanism was overcome with the later design illustrated and described by this article.

Modern Stoker Equipment Developments

Discussion of Operating Tendencies and of Influences Affecting Stoker Operation.* By G. W. Moran and C. F. Hirshfeld†

THIS DISCUSSION is confined to the forced-draft chain grate and multiple retort underfeed types of heavy duty stokers. Both of these types, as they exist today, are the temporary solutions arrived at in an evolutionary process and they probably do not represent their ultimate development. It is this fact of constant change and generally, constant improvement, that makes it exceedingly difficult at any given time to make that fine economic balance that is called for in deciding between different methods of firing. It is always particularly difficult to differentiate between that which is proven fact and that which is the hope or wish of the stoker designer and builder.

Influence of Fuel Type on Stoker Operation

Forced draft traveling grates were developed in two different sections of the country and for two different purposes. In the region in which the present meeting is being held, this type of stoker was developed for the burning of the types of fuel mined in the neighborhood. These fuels are characterized by low softening temperature of the ash and usually by comparatively high water and ash contents and low heat value per unit of weight. They are also non-coking coals in the ordinary meaning of that expression.

In the eastern section of the country, a somewhat similar type has been developed for burning the smaller sizes of anthracite. This coal is characterized by very low volatile content, high ash content, high ash softening temperature and, frequently, fairly high moisture content. The sizes are generally small and are constantly getting smaller as the ability to burn small sizes becomes greater.

These traveling grates are definitely not well adapted to the burning of coals containing small amounts of ash, as a certain rather large quantity of refuse is required to protect the grate itself. Also, if reasonably good efficiency is desired, the discharge end of the chain should be fairly well covered to prevent excessive air leakage into the furnace in that region.

Underfeed stokers of the modern multiple retort type were developed primarily for burning the better grades of bituminous coals with rather low ash content of high softening temperature. During the past few years, however, models have been produced which give satisfactory performance with Illinois and similar varieties of coal. This type of stoker appears to be undergoing the most rapid improvement at the present time, both with respect to increase of size, increase of fuel burning capacity, improvement in thermal performance and improvement with respect to operating convenience and maintenance.

Factors Other Than Stoker Must Be Considered

Beginning about 20 yr. ago, there was a definite movement toward increased size of steam generating units and increased steam output per square foot of boiler surface. This in turn brought about both increase of stoker size and increased size of furnace, particularly with respect to furnace height. The weak point at this stage of the development was the refractory which was being subjected to more severe usage and which definitely set a limit to possibilities. Then we resorted to air, water and steam cooling of furnace walls and even furnace arches.

At about this same time, we began the use of preheated air. As a matter of fact, the driving force behind this development came through a change in the type of steam cycle, but we may here ignore the cause and consider only the result. At first it was assumed that the use of preheated air would yield only an approximation to a certain calculated thermal saving, the calculation being based upon the degree to which the temperature of the flue gases could be lowered by this means. It was, however, early discovered that the use of preheated air resulted in rather remarkable improvement of combustion so that an unexpected gain was realized. The use of preheated air and the use of water-cooled surfaces in the furnace are really tied together to a certain extent.

Limitation of Air Temperature

There is still much discussion as to the maximum permissible temperature of preheated air in stoker firing. At present we prefer to limit the temperature of preheat to about 300 or 350 deg. F. We do not mean that it is necessarily impossible to operate with higher values; this has in fact been done and is being done today. We mean simply that we believe that under what we may call normal conditions, much more certain and satis-

*Abstract of paper presented at the Fourth Midwest Power Engineering Conference.

†Research Department, Detroit Edison Co.

factory results with minimum investment and minimum maintenance are expectable with the lower values.

Stoker design must be modified for different air temperatures. The stoker which is properly proportioned and designed for use with air at room temperature will not in general perform satisfactorily with high preheated air, and vice versa. Use of highly preheated air sometimes changes radically the way in which fuel acts on the stoker.

Size and Capacity Increase

Increase of stoker dimensions has occurred both in width and length. Increase of width may be said to increase the fuel burning capacity in direct proportion. This is accurately true except for a slight difference due to the diminishing effect of side wall conditions as a per cent of the total as the stoker gets wider. Increase of length, on the other hand, produces more than a proportionate increase in fuel burning capacity; at least up to a certain limit not yet determined.

In the case of the chain grate the increase of width and length bring in serious design problems, both of a purely mechanical character and also with respect to air distribution. In the case of the multiple retort stoker, increase of width is a comparatively simple matter but increase of length brings up problems of mechanical strength, of adequate coal feed and of adequate coal forwarding.

Increase in coal burning capacity per stoker fired furnace during the past few years is well shown at A, Fig. 1, in which results obtained with both chain grates and underfeed stokers have been combined. The curves given in Fig. 1 are presented only as indicative of trends. They are definitely not intended as bases for design. More significant is the curve shown at B in which the total heat release per furnace is shown, thus eliminating variations in heat value of coal. It will be observed that both figures have approximately quadrupled in a period of 13 yr. The data presented in curve shown at C illustrating the increase in the rate of heat release per square foot of grate surface over the same period shows a much less rapid change. It must be inferred that a great part of the increase of output per furnace has resulted from increasing the dimensions, rather than from increasing the intensity of use. The two points which represent 1929 values are seen to fall much below the position which they would be expected to occupy. They really represent conservative estimates of performance to allow for a number of unknown factors. If the stokers actually prove capable of burning at the rate indicated by the curves, A and B would have to be modified accordingly.

Rate of Heat Release Will Increase

It has long been known that stoker fired equipment is not so limited with respect to rate of heat release per unit of furnace volume as is equipment fired with pulverized fuel. Cases are on record in which reasonably good results have been obtained with stoker fired furnaces in which the rate of heat release approached 100,000 B.t.u. per cu. ft. per hr. Most modern stoker fired boilers, however, have been provided with much more liberally proportioned furnaces. It is impossible to give any simple rule for furnace volume. Too many variables are concerned. We may say that as walls are better protected with air-cooled, water-cooled or steam-cooled surfaces and as more highly preheated air is used, the rate of heat release per unit of volume may increase without materially affecting the operating results. The principal limit is set by the tendency to deposit fused ash on the boiler tubes nearest the furnace. This can be obviated by the use of an adequate slag screen arrangement; that is by the use of one or more rows of widely spaced tubes which cool the molten fly ash before it strikes closely spaced tubes.

Improvements in furnace construction have affected the rate of heat release in recent years, as shown at D. The general trend was toward smaller furnaces from 1915 to 1924, after which the relative size has remained about constant. The effect upon the boiler of high rates of heat release per furnace and per unit of furnace volume is shown graphically at E. Apparently we have increased the boiler area more rapidly than we have the rate of heat release per furnace. This is equivalent to saying that we have not operated boilers at such successively higher rates of output in recent years as is

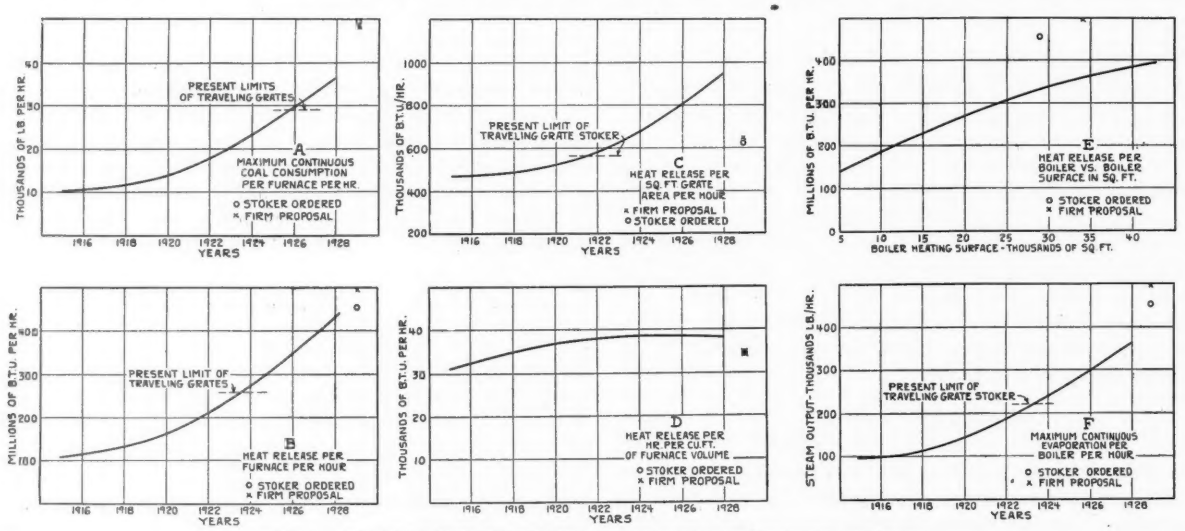

THOUSANDS OF LB. PER HR.
PRESENT LIMITS OF TRAVELING GRATES
A
MAXIMUM CONTINUOUS COAL CONSUMPTION PER FURNACE PER HR.
o STOKER ORDERED
× FIRM PROPOSAL
YEARS
THOUSANDS OF B.T.U./HR.
PRESENT LIMIT OF TRAVELING GRATE STOKER
C
HEAT RELEASE PER SQ. FT. GRATE AREA PER HOUR
▲ FIRM PROPOSAL
o STOKER ORDERED
MILLIONS OF B.T.U. PER HR.
E
HEAT RELEASE PER BOILER VS. BOILER SURFACE IN SQ. FT.
BOILER HEATING SURFACE - THOUSANDS OF SQ. FT.
PRESENT LIMIT OF TRAVELING GRATES
B
HEAT RELEASE PER FURNACE PER HOUR
THOUSANDS OF B.T.U. PER HR.
D
HEAT RELEASE PER HR. PER CU. FT. OF FURNACE VOLUME
STEAM OUTPUT-THOUSANDS LB./HR.
PRESENT LIMIT OF TRAVELING GRATE STOKER
F
MAXIMUM CONTINUOUS EVAPORATION PER BOILER PER HOUR

FIG. 1. GRAPHIC REPRESENTATION OF CERTAIN STOKER TRENDS

popularly believed. In a few cases there has been a remarkable increase of boiler rating, the tendency toward lowered thermal efficiency having been balanced by the extensive use of economizers and air preheaters. The points indicated respectively by a circle and a cross represent cases of this sort.

Increase in Unit Steam Production Is Rapid

Increase in the quantity of steam produced per furnace is shown at F. While it is true that the highest values shown by the two isolated points do not as yet represent accomplished facts, it should be noted that one does represent an actual order placed. It is also true that the limit to steam output in the case of some of the highest values indicated by the curve is fixed by things other than the stokers, so that the upper values can probably be exceeded in so far as the stoker is concerned. It is certainly a far cry from the "large Delray boilers" of 20 yr. ago with an output of about 140,000 lb. of steam per hour to the unit now available and capable of producing 500,000 lb. per hr.

Typical arrangement of forced draft chain grate of the largest size, as used with Illinois coal, is shown in Fig. 2. The small extent of the uncooled refractory arch and the extensive use of water cooled surface are notable developments in this class of stoker. This represents one of the largest installations of its type being designed to produce 150,000 lb. of steam continuously and to carry peaks of 190,000 lb. The stoker pictured is 24 ft. wide by 20 ft. 6 in. long, giving a total area of 490 sq. ft.

Design of Arch Influences Operation

An arrangement of the forced draft chain grate, as used with small sizes of anthracite, is shown in Fig. 3. The reversed arch over the discharge end of the stoker is a characteristic feature of this type of furnace. The construction shown in full lines was adopted after that shown in dotted lines was found to have undesirable operating characteristics and limitations. The original

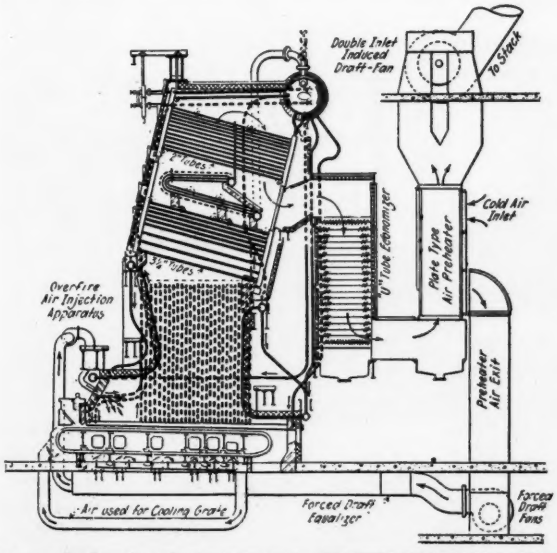


FIG. 2. SECTION OF CRAWFORD AVENUE STATION BOILER SHOWING SMALL EXTENT OF UNCOOLED REFRACTORY AND EXTENSIVE USE OF WATER-COOLED SURFACE

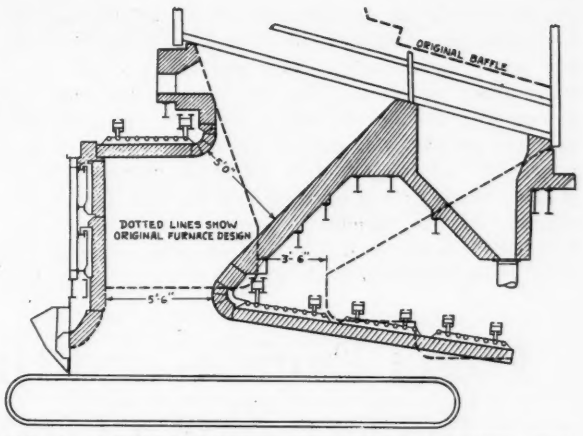


FIG. 3. REARRANGEMENT OF ARCH IMPROVES COMBUSTION IN CHAIN GRATE STOKER BURNING SMALL SIZES OF ANTHRACITE COAL

design had a throat of only 3 ft. 6 in. The later design gives a much wider throat with a long rear arch and almost no front arch. It was found that the lean and rich gases mixed very satisfactorily and combustion was more nearly complete with the second arrangement. Combustion rates as high as 75 lb. per sq. ft. per hr. have been attained with this design but the fuel bed must be thin and the stoker speed high (about 100 ft. per hr.) in order to maintain this rate.

In Fig. 4 is shown a modern arrangement of a multiple retort stoker as applied to bent tube boilers in an English power plant. This is an 11-retort, 37-

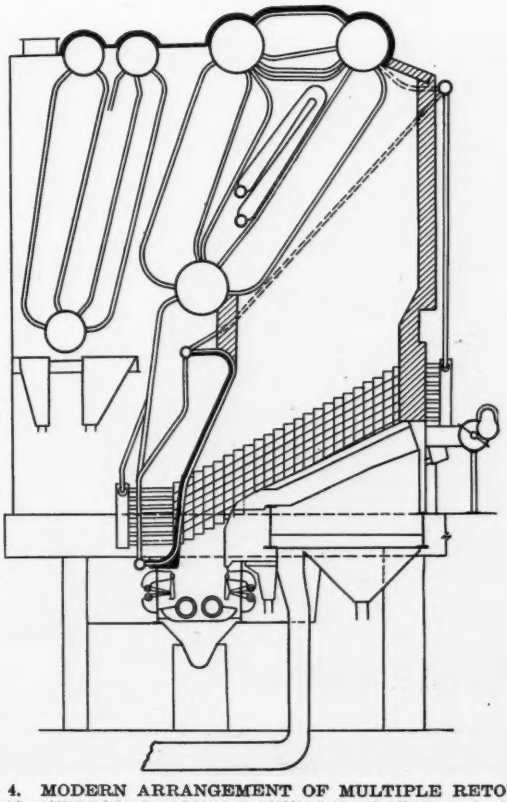


FIG. 4. MODERN ARRANGEMENT OF MULTIPLE RETORT STOKER AS APPLIED TO BENT TUBE BOILER

tuyere stoker. A similar unit of 17 retorts and 49 tuyeres is being built to produce 350,000 lb. of steam per hour continuously. The cast iron covered water tubes along the clinker line and those which form the bridge wall are particularly noticeable. In this way, the most critical wall sections are amply protected in a relatively inexpensive but effective manner, while cheaper masonry construction can be used for the remainder of the furnace enclosure. Incidentally, the front wall construction shown is not to be recommended as it may be expected to have a comparatively short life.

Influence of Method of Coal Distribution

It is important to distribute coal properly to a stoker. The stoker cannot be held responsible for results if coarse coal is fed to one or two retorts and much finer coal to the neighboring retorts. This fact has been known for a long time and appreciated by some but ignored by most. There are now several different devices on the market which are capable of producing a satisfactory distribution of coal in the stoker hopper and we believe that they should be used more frequently than they now are.

Diesel Engines and High-Speed Ice Machines Replace Slow-Speed Steam-Driven Plant

MODERN ADJUSTMENTS in the power field often require the displacement of machinery which, although in good operating condition, has become obsolete due to rapid advancement of modern design. This was the condition found by the new owners of the plant which is now controlled by the Arlington Ice & Fuel Co. of Baltimore.

While the ice machines of the plant were in good working condition, they were of slow and cumbersome type. The steam plant, however, was completely run down and substitution of Diesel engines was desired. It was estimated that the cost of connecting the old ice machines to Diesel engines would be about the same as the cost of new high-speed, direct-connected ice machines, so the latter were purchased.

Three 110-hp. four-cycle, solid fuel-injection, three-cylinder, vertical, Bessemer Diesel engines running at 300 r.p.m. were installed. Two of these are direct connected to 2-cylinder, vertical, 10 by 10-in. York ice machines which are rated at 40 t. ice at 300 r.p.m. and 20 lb. back pressure against 185-lb. head. The number 3 engine is direct connected to a 75-kw., 60-cycle, 220-v. General Electric alternator. A 5½-kw., 125-v. compound-wound, direct-current General Electric exciter is belted to this unit. The demand cost for power purchased from the public utility company being one-half maximum load, provision against need of purchasing any power was made by belting a duplicate generator to the number 2 engine, so that in case of emergency the auxiliary generator could be operated without delay. This generator is a 90-kw., 60-cycle, 3-phase General Electric alternator operating at 1200-r.p.m., direct-

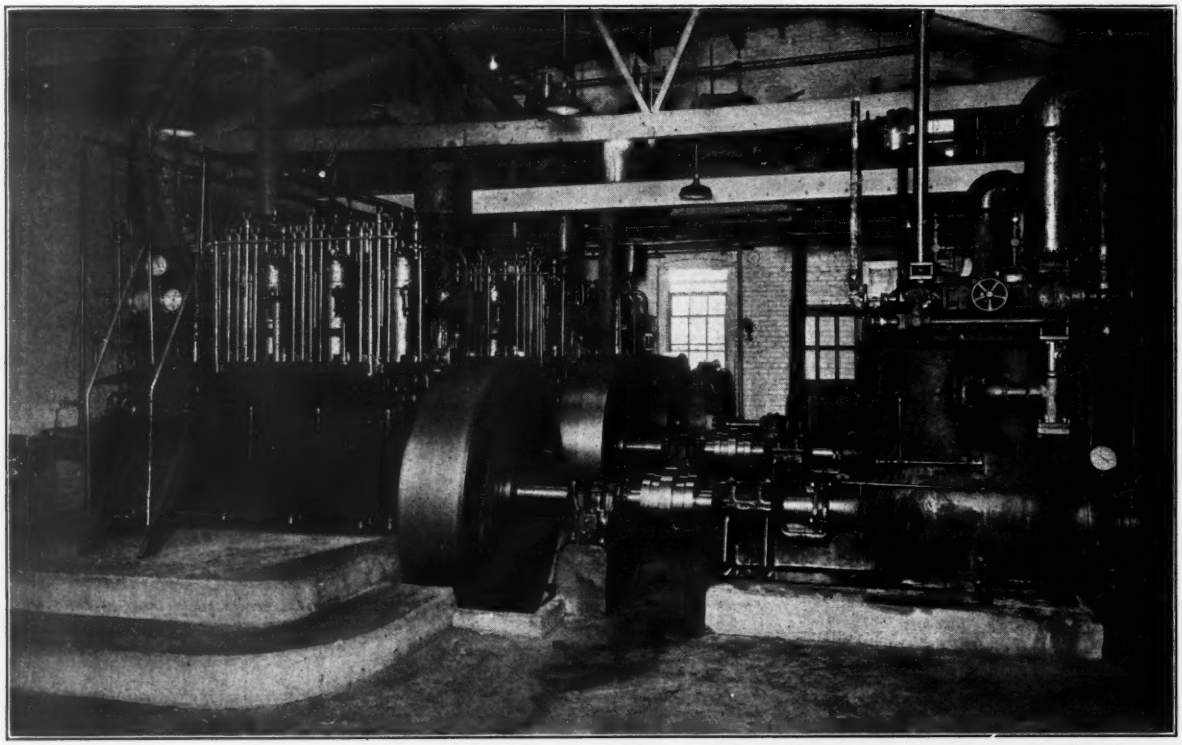


FIG. 1. DIESEL ENGINES DIRECT CONNECTED TO ICE MACHINES MAKE UP COMPACT AND CONVENIENT PLANT

connected to a 4-kw., 125-v., direct-current General Electric exciter.

City water is used as makeup water for the cooling system, which is of the closed type. The cooling water runs by gravity from the engine to a collecting tank from which it is drawn by a Goulds centrifugal pump which delivers the water to the top of a cooling tower. No water treatment has thus far been found to be necessary.

Use Made of Dehumidifier Waste

Water condensed from the air and collected in a dehumidifier, which is connected with the ice plant, instead of being wasted as is customary practice, is added to that in the makeup tank in the cooling tower. A No. 202 DeLaval centrifugal separator is used for reclaiming lubricating oil and a No. 302 DeLaval separator is employed for purifying the fuel oil.

Fuel oil costing five cents a gallon and having a gravity of 22 deg. Beaumé is used. Fuel as received flows by gravity into an underground 15,000-gal. steel tank, whence the oil is pumped by duplicate motor-

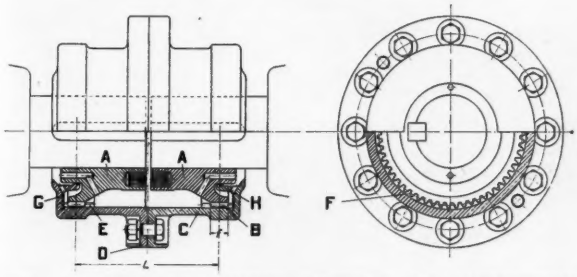


FIG. 2. SELF ALINEMENT SECURED BY CONNECTION THROUGH FLEXIBLE COUPLING

driven, size 2, Blackmer rotary pumps into the day tank which is located on the platform shown in the illustration. Manifold cooling of exhaust gas is employed.

Advantage of complete equipment of gages is illustrated by the experience encountered in this plant when the temperature and pressure in the ice machine suddenly ran up very high. Immediate investigation disclosed the fact that the water which had been supplied to the cooling tower had been shut off, thus permitting the tower basin to be drained. Prompt action avoided breakage or other destruction.

Geared Coupling Secures Alinement

Self-alinement of engine and driven unit is accomplished by means of a Fast coupling, manufactured by Bartlett Hayward Co., shown in Fig. 2, which consists of two hubs A, each keyed to its respective shaft. Each hub has a generated spur gear, B, cut at the maximum possible distance from the shaft end. Surrounding the hubs is the casing, C, which is transversely split in its center and bolted together by means of flanges, D. Each half of this casing has a generated internal spur gear, E, cut on its bore at the end opposite its flange. Supporting rings, G, positively control the center line of each shaft, intercepting the center line of the casing at the transverse center lines through the load carrying surfaces. A slight clearance between the external and internal gears permits a definite error of alinement between the two shafts. The coupling is packed with heavy grease.

Production of Fuel Briquets in 1928

PRODUCTION of fuel briquets in this country in 1928 amounted to 947,423 t., valued at $7,705,617, states the Department of Commerce in summarizing reports furnished to the United States Bureau of Mines by the operators of briquetting plants. This represents a decrease of 2.4 per cent from the 1927 production of fuel briquets but is an increase of 12.9 per cent over the 1925 output.

Despite an abundant supply of both anthracite and bituminous coal throughout 1928, briquet sales declined only 4.8 per cent from the high level set during 1926, when demand was greatly stimulated by the anthracite strike. That a large proportion of the gain in production made during the strike period was retained in 1927 and 1928 is an indication of stability and progress in the briquetting industry.

In the Eastern States, production of briquets increased 16 per cent in comparison with 1927 but the output declined in the Central and Pacific Coast States. The seasonal character of house heating makes the production of fuel briquets also highly seasonal. In 1928, the minimum production was reached in July, when 30,335 t. were produced, which is about ¼ of the maximum output of 122,157 t. in December.

The average value of fuel briquets f. o. b. producer's plant in 1928 for the Central States, in which the operations at the head of Lake Superior were the largest element, was $8.38 a ton, an increase of 8 cents over 1927 prices. The average value for the State of Pennsylvania was $6.38, a decrease of 14 cents below 1927.

The total quantity of raw fuel used in the production of briquets in 1928 was 940,806 tons. Of this, 40 per cent was anthracite and semianthracite; 52 per cent was semibituminous and bituminous coal and semicoke; and 8 per cent was subbituminous coal (black lignite) and carbon residue from the manufacture of oil gas.

Asphaltic pitch was employed as a binder either alone or in combination by 13 out of the 21 plants active in 1928. Two plants briquetting oil-gas carbon required no binder.

Twenty-one briquet-making plants were in operation in 1928, the number being two more than in 1927.

Imports of fuel briquets in 1928 were 71,485 tons, an increase of 10,884 tons, or about 18 per cent, over 1927. They were less, however, than the record of 123,593 tons made during the unusual conditions of 1926. About 97 per cent of the total importations in 1928 were received at Massachusetts ports, and 95 per cent of the total originated in Germany and The Netherlands.

Provision of 280,000 lb. a day of high-pressure steam is being undertaken at the Court St. plant of the Consumers Power Co., Flint, Mich., by means of a dry-quenching coke plant, to be installed by the Dry Quenching Corp. of New York and Stevens & Wood, Inc. Saving of heat wasted in wet quenching, reduced maintenance charges, elimination of freezing in cold weather and a better grade of domestic coke are the advantages sought. Capacity of the first installation is for 280 t. of coke a day with provision for expanding to 500 t. a day capacity and corresponding increase in steam production.

Design Factors of the New Gorgas Steam Plant

COST ESTIMATES AND CONCLUSIONS REACHED BY THE ALABAMA POWER CO. WHEN CONSIDERING THE ADDITION OF GENERATING EQUIPMENT TO MEET ITS RAPIDLY GROWING LOAD. BY JOHN GALLALEE*

LOOKING FORWARD from 1926, there was every evidence that the rate of growth of the Alabama Power Co. load would continue and that despite a heavy construction program in hydroelectric plants, that additional steam generating facilities must be provided in 1929 if the system was to meet its obligations to customers during dry periods.

With the knowledge that an additional steam plant must be ready to run in 1929, a decision had to be made in 1927 on the type and on the location for a plant to deliver to a load center or load centers the necessary energy at the lowest total cost in fixed charges, in fuel, in operation, in maintenance, in transmission lines and in line losses.

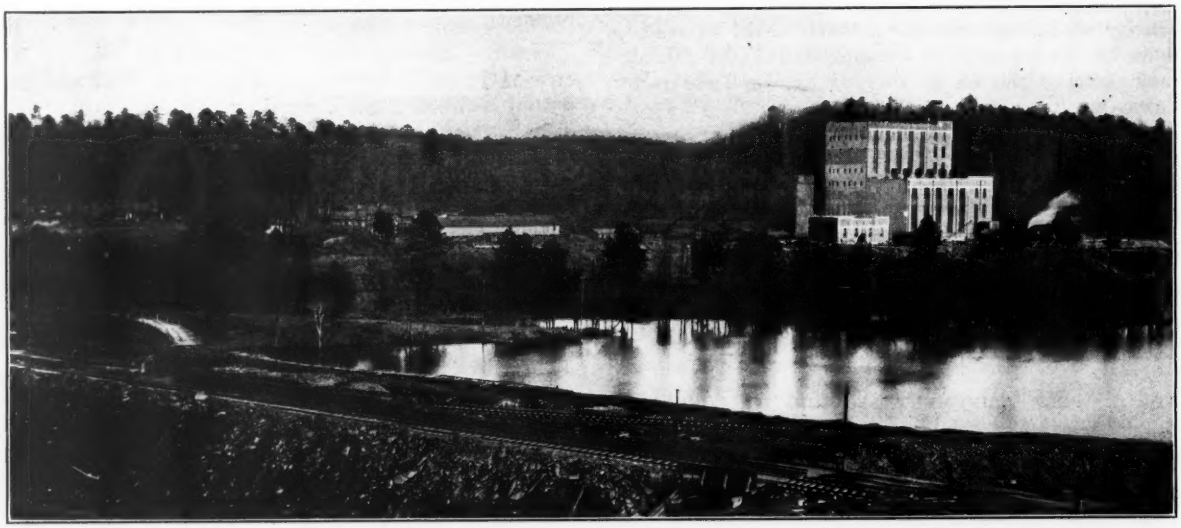


FIG. 1. GENERAL VIEW OF THE NEW GORGAS STEAM PLANT OF THE ALABAMA POWER CO.

An extended study of the past performance of the hydroelectric plants in operation, of what was to be expected of hydroelectric plants being built, or planned for the future, together with a study of the past performance of Gorgas steam plant, Units 1, 2 and 3 (the first unit of which is now 12 yr. old), led to the conclusion that the capacity factor of the new steam plant would not exceed 40 per cent over a period of 15 yr., though its capacity factor might be 70 per cent in a dry year.

A study of the transmission system, together with a survey of the coal fields and of rivers with adequate condensing water, led to the conclusion that the new plant should be located on the Warrior River and not far from the old Gorgas Steam Plant. This location offered the following advantages: (a) it is in the Warrior coal fields; (b) due to the seasonal operation of the steam plants, the run-of-river hydro plants and the storage hydro plants, it was the only location for as much as 50,000-kw. additional capacity without expensive transmission line construction; (c) condensing water could be made available; (d) no other location on the system offered condensing water and commercially operated coal mines in close proximity; (e) energy from a large steam plant could be transmitted, in the future, to load centers with minimum transmission line costs.

Before a definite decision was reached on the plant location, estimates were made on the cost of building and operating a plant with a cooling pond and located in a coal field where little water was available but which was close to large load centers. The estimate disclosed that a large plant with a cooling pond would cost $5.00 more per kilowatt of capacity than a plant located on the Warrior, that the cost of station service would be greatly increased and because of the locations and capacities of the existing transmission lines, that a steam plant so located would not be of as general service, nor could its energy be produced as cheaply as energy from a plant located on the Warrior River.

Further study led to the conclusion that the new plant should be located as close as possible to the old plant, but that because of foundation conditions and lack of ground, that it should not be located adjacent to the old plant, nor made a part of the old plant. As located, the new plant is across Baker's Creek from the old plant.

Factors instrumental in the selection of this site were:

1. Ample condensing water can be made available for new and old plants, and the old plant furnished with alkaline water for make-up rather than the acid water from Baker's Creek. The old plant has two jet condensers.

*Professor of M. E., University of Alabama, and Consulting Engineer, Alabama Power Co. From a paper presented before the A.S.M.E. at Knoxville, Tenn.

2. Coal mines operated by the Southeastern Fuel Company are immediately adjacent and coal is mined in great quantities by the fuel companies on the river above and below the site. The river is navigable.

3. The coal storage facilities and coal mining and washing facilities of the old plant can be used to serve the new plant. Coal is mined and transported without use of a common carrier.

4. A standard gage railroad connects the old plant with the Southern Railway at High Level, Alabama. This railroad was easily extended to the site of the new plant. The branch of the Southern Railway on which High Level is located serves a large coal mining section and coal can be furnished the plant by rail from outside mines at minimum freight charges.

5. The filtered and treated domestic water supply of the village of the old plant could be extended to serve the operators' houses for the new plant. It was cheaper to operate one large village than two smaller villages.

6. Joint operation of the two adjacent plants was cheaper for superintendence, services, and overheads than separate operation of two plants.

7. Good rock at the right elevation for foundations.

Coincident with studies on plant location and inextricably involved with them, were the estimates and studies to determine the pressure for which the plant was to be built. After much preliminary work on layouts, estimates and heat balances, three cycles were selected for extended study. These were:

1. Plant A. 450 lb., 725 deg. F., at the boiler to 28-in. vacuum straight regenerative with three bleed points.

2. Plant B. 650 lb., 725 deg. F., at the boilers to 28-in. vacuum with boiler reheat, and three bleed points.

3. Plant C. 1400 lb., 725. F., at the boilers to 28-in. vacuum with boiler reheat, and three bleed points.

The first was similar to many stations; while the second type of plant had been standardized at Chicago, at Columbia and at Philo. At the time the estimates were made, 1200-lb. pressure turbo-generators had been added to 350-lb. pressure plants at Boston and at Milwaukee, and the 1400-lb. boilers had been purchased for Kansas City, but no 1200-lb. pressure plant, as such, had been built, though rumors were rife as a result of the studies for Deepwater, and of the experiences at Boston and Milwaukee, that a 1200-lb. pressure plant could be built for the same cost per kilowatt as a 400-lb. pressure plant. The performance of the 1200-lb. station could be calculated but it was felt that the operating expense of others, as a check, was decidedly limited and there was then, and there is now, a doubt that the operation and maintenance costs for the 1200-lb. station could be as closely predicted as for the 450-lb. station.

TABLE I. COST ESTIMATES FOR 450,650 AND 1400-LB. PLANTS

Plant A - 2-60,000 kw. turbo-generators - 450 lb.
Plant B - 2-52,500 kw. turbo-generators - 650 lb.
Plant C - 2-12,500 kw. and 2-43,000 kw. turbo-generators - 1400 lb.

	Plant A 120,000 kw. 450 lb.	Plant B 105,000 kw. 650 lb.	Plant C 111,000 kw. 1400 lb.
Land, buildings and village	$2,320,000	$2,360,000	$2,100,000
Boiler-plant equipment	2,430,000	2,330,000	2,720,000
Turbo-generator equipment	1,730,000	1,610,000	1,780,000
Condensers and auxiliaries	625,000	575,000	550,000
Station piping	790,000	900,000	1,140,000
Condensing water system	715,000	700,000	650,000
Feedwater system	312,000	350,000	460,000
Coal handling	468,000	450,000	435,000
Service equipment	163,000	165,000	165,000
Electrical & Substation equipment	1,880,000	1,640,000	1,740,000
Total Cost	$11,433,000	$11,080,000	$11,740,000
Cost per kw. of capacity	$95.30	$105.30	$106.90
B.t.u. per kw.hr. sent out at 40 per cent yearly capacity factor	16,000	14,800	14,200

Costs do not include interest and some administrative overheads

Equipment drawings were obtained from manufacturers, detailed layouts and estimates of cost were made for the three types of plants selected for final study. Summaries of three typical estimates are given in Table I.

TABLE II. BOILER GUARANTEES OF THE 475-LB. UNITS SELECTED

Steam Output lb. per hr.	Steam Temp. Deg. F.	Press.Loss In Superh.Lb.	Draft Loss,In.	Exit Gas Temp.Deg.F.	Exit Gas CO_2%	Boiler Eff.%
100,000	665	1	0.25	480	15.75	82.5
300,000	720	10	2.10	635	15	79.5
450,000	740	22	6.00	770	14	73.5

It was known that the plant would be called upon to operate close to 100 per cent capacity factor for some months each year, at lower capacity factors for some months, and to produce no energy for some months each year throughout the course of its life. This kind of operation would make for excellent economy at times but for very poor economy at the low load periods. As has been stated before, it was concluded that the plant would operate on a yearly load factor of about 40 per cent. For this load factor it was estimated that the three types of plants would deliver a kilowatt-hour to the high-tension side of the substation transformers for 16,000 B.t.u. for Plant A, 14,800 B.t.u. for Plant B and 14,200 B.t.u. for Plant C.

These results were predicted on the assumption that an unwashed Alabama coal of 11,400 B.t.u. value and

TABLE III. AIR HEATER GUARANTEES AS TAKEN FROM THE CONTRACT

Steam Output lb. per hr.	Gas Temp.Deg.F. In	Out	Air Temp.Deg.F. In	Out	Added Eff.%	Overall Eff. Boiler,Furn.& Air
160,000	525	343	80	372	4.3	86.8
300,000	635	421	80	422	5.2	84.7
350,000	680	451	80	445	5.7	83.7
400,000	770	512	80	492	6.6	80.1

containing from 16 to 20 per cent ash would be burned directly from the mines for two-thirds of the station output and that a washed coal containing 12,300 B.t.u. and 12 per cent ash, would be burned from storage for the remaining third of the output. The unwashed coal cannot be stored without danger of fires.

It was concluded from the load studies, from the estimates of cost and from the predicted performances for the types of stations studied and from an estimate of the cost of coal at the plant, that the plant should be built for 450 lb. pressure, that its initial capacity should be 60,000 kw. in one unit, that it should be designed for an ultimate capacity of about 240,000 kw. A 60,000-kw. turbo-generator was purchased.

Any person interested can modify the estimates of cost and the station performance to suit an assumed capacity factor, can assume a cost for coal and determine for the assumed conditions whether a 450-lb. plant or a 1400-lb. plant should be built. There seems to be a decided trend away from 600-lb. or 650-lb. pressure plants.

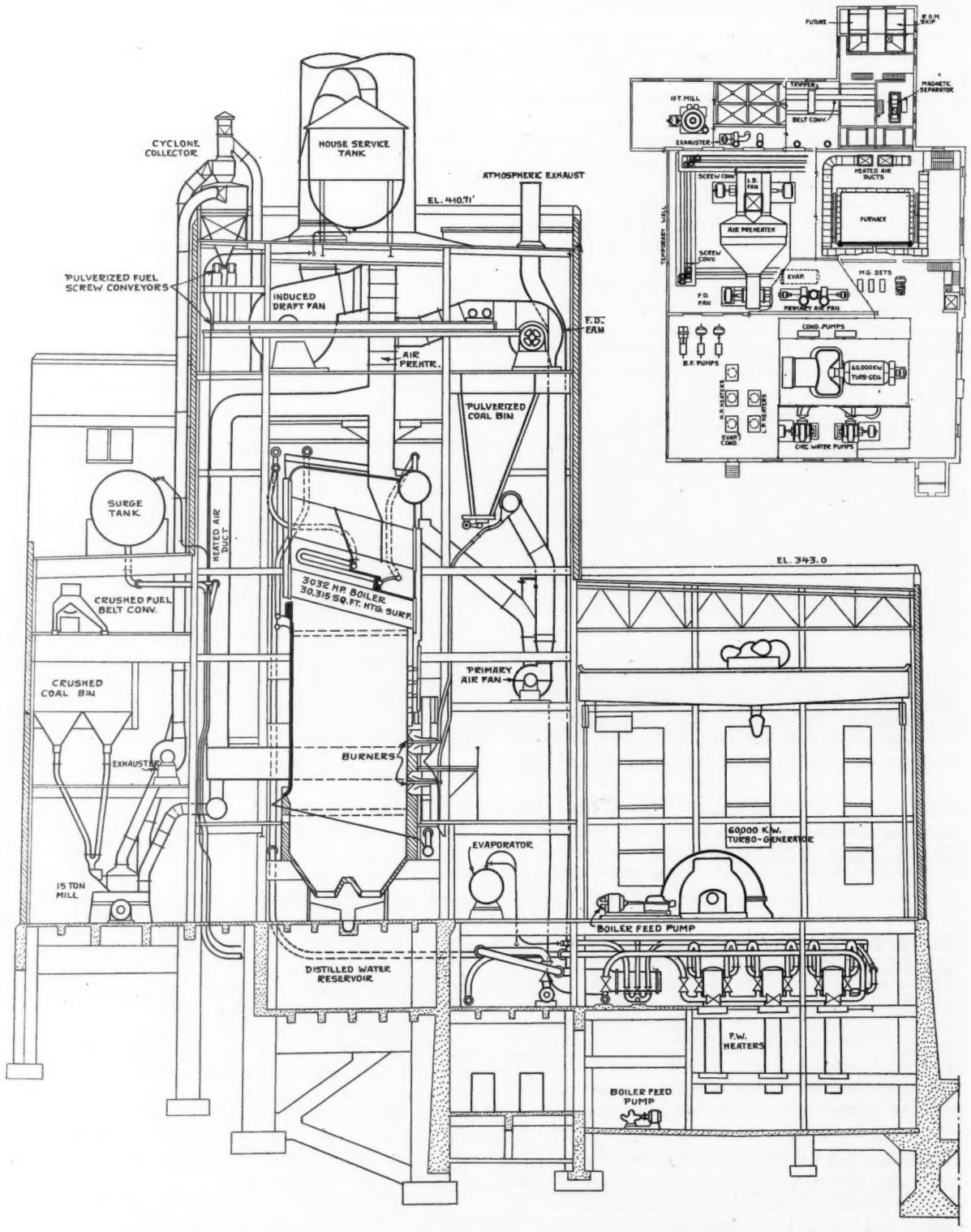


FIG. 2. CROSS-SECTION AND SECTIONAL PLAN OF THE NEW GORGAS STEAM PLANT

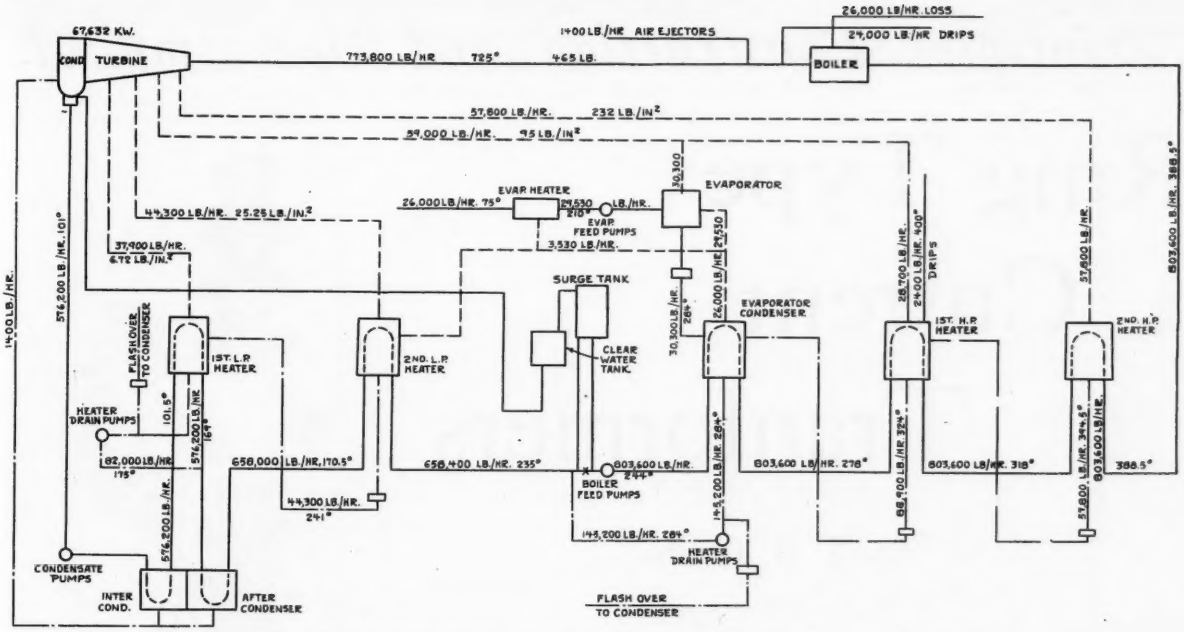


FIG. 3. FULL LOAD HEAT BALANCE FOR NEW GORGAS STEAM PLANT

Detailed estimates based on sealed bids on boilers, fuel preparation, fuel transport and burning equipment, on stokers and on air heaters, and involving the plant building, led to the purchase of:

2—30,320-sq. ft. Babcock & Wilcox, cross-drum boilers for 475 lb. pressure, drums 72 in. dia. by 34 ft. long. Tubes 4 in. dia., 51 wide by 20 high, 24 ft. long with 3505 sq. ft. of Combustion Eng. Corp. fin tube on three sides and bottom of the furnace. The front wall is Detrick suspended construction. The furnace is 30 ft. wide, 22 ft. deep, and the distance from the hearth screen to the lowest boiler tubes is 38 ft.

3—15-t. Raymond 6-roll mills with cyclones, screw conveyors and feeders for the bin system of firing.

16—Combustion Eng. Corp., No. 7.5 cylindrical burners (8 per boiler).

2—30,600-sq. ft. Combustion Eng. Corp. plate-type air heaters with elements 18 ft. high, 5 ft. wide, with spacing of 1 in. in the gas section and ¾ in. in the air section.

Embodied in the boiler contract is the boiler performance given in Table II with drum pressure at 475 lb., while Table III gives similar data for the air heater.

Selection of the fans gave the designers great concern for the following reasons:

1. With one boiler out of service because of sudden breakdown, the other boiler should produce continuously 450,000 lb. of steam per hour, i. e., operate at about 500 per cent normal rating.

2. There was no assurance felt that the resistance through dirty boiler and air heater could be definitely predicted.

3. Some doubt existed that high CO_2 could be held at the highest ratings.

4. Boiler-room layout and boiler spacing did not lend themselves to the installation of two induced-draft fans per boiler.

5. Slip-ring motors or wound-rotor motors and their controls are costly.

6. There were stations built recently in which the fans definitely limited the capacity of the boilers below the designed capacity because of higher resistances than were guaranteed and because of inability to maintain high CO_2.

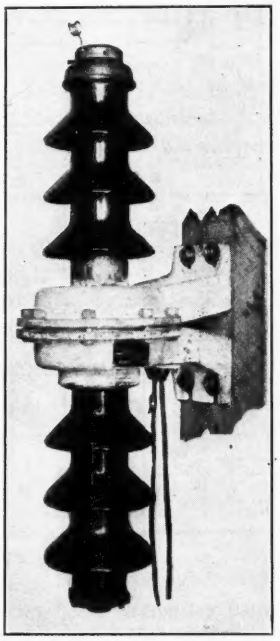
For each boiler, one induced draft fan was selected with a capacity of 358,000 c.f.m. at 18 in. static pressure with vane control and connected at one end of the shaft to a 900-hp. induction motor and to an 1800-hp. induction motor at the other end of the shaft. One forced-draft fan was selected for each boiler with a capacity of 166,000 c.f.m. at 14 in. static pressure, with vane control. It is connected to a 700-hp. induction motor. If these fans, and others like them which are now being installed, behave as they are expected, then another advance will have been made in steam-station design. No other features are unusual in the design of the station.

This new plant schedule for operation in May, 1929, is shown in plan and cross section in Fig. 2 while Fig. 3 is heat balance and flow diagram based on full load operation.

RESULTS of an investigation of the washing characteristics of coals from many of the important coal fields of the Eastern and Central States, made by the United States Bureau of Mines, Department of Commerce, in coöperation with the University of Illinois and the Carnegie Institute of Technology, will soon be issued as a Bureau bulletin. Tests were conducted with jigs, concentrating tables, and pneumatic tables but, on some few coals, the tests were confined to an estimation of the washing characteristics by specific gravity analyses made by the float-and-sink method. The various coals examined have been arranged in typical groups, on the basis of the occurrence of the impurities associated with the coal in the bed and the results of tests of one or more well-known beds of each type are given. By classifying any other coal as to type and comparing it with the test data obtained, a rough idea of its amenability to washing is had, as well as a general estimate of the method of washing required.

Principles, Construction and Operation of

Ring Type Current Tranformers



By J. B. Gibbs
Transformer Engineer
Westinghouse Electric & Mfg. Co.

OF ALL PIECES of electrical apparatus, the ring type current transformer is one of the most simple and rugged but it causes an amount of discussion and worry out of all proportion to its size. The reason is that its field of application is not clearly defined and limited and the temptation is strong to apply it in the "twilight zone" where its performance is questionable.

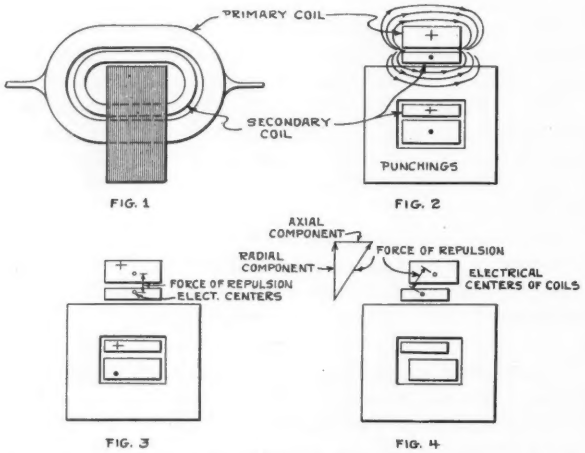


FIG. 1 FIG. 2 FIG. 3 FIG. 4

FIGS. 1-4. DIAGRAMS OF WOUND TYPE CURRENT TRANSFORMERS SHOWING LEAKAGE FLUX AND INTERNAL STRESSES

Fig. 1. Simple, wound type current transformers. Fig. 2. Section through transformer shown in Fig. 1 showing the leakage flux. Fig. 3. Section through transformer showing direction of forces acting between coils. Fig. 4. When coils are slightly displaced, the forces tend to move the primary coil axially along the secondary.

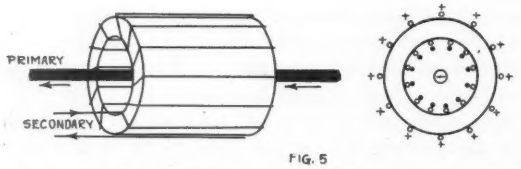


FIG. 5

FIG. 5. VIEW AND SECTION OF A RING TYPE CURRENT TRANSFORMER

Performance of any current transformer depends on the exciting current of its core,—the larger the exciting current in proportion to the output, the higher the ratio and the greater the phase angle. Improved performance, therefore, depends upon reducing the exciting current. This can be done in several ways: (1) An improved grade of iron may be used. Considerable progress has been made in recent years in reducing the losses and increasing the permeability of transformer iron. (2) Another way to decrease the exciting current is to increase the cross section of the iron. This helps but the gain is not so rapid as might be expected, because, although the flux-density in the iron is reduced, the weight of iron is increased at the same time. (3) A third method is to increase the number of primary turns. This is the method used in wound type current transformers. It is effective in reducing the exciting current but it increases the mechanical stresses to which the transformer is subject.

Effect of Short Circuit Stresses in Current Transformer

Figure 1 illustrates a common form of wound type current transformer. The primary and secondary coils are concentric and surround one leg of a rectangular iron core. Such a transformer at rated current may have about 1200 amp. turns. Its accuracy is good and under usual operating conditions, including ordinary short circuits, it is strong enough mechanically. If the circuit, however, is subject to very severe short circuits, the transformer may be in danger.

For instance, in a transformer like Fig. 1, having 1200 normal ampere turns, a short circuit current of 100 times the rated current will cause a force of something like 20,000 lb. between the coils. It must be re-

membered, however, that short circuits of 100 times rated current are impossible in many circuits because of the inherent impedance. It is only in exceptional cases that such currents occur and in such cases specially braced transformers are used.

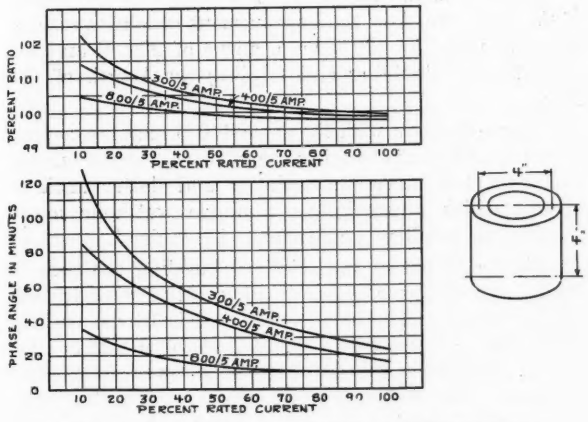


FIG. 6. RING TYPE CURRENT TRANSFORMER CHARACTERISTICS

Mean diameter ..... 4 in.
Length ..... 4 in.
Gross area ..... 4 sq. in.
External burden, 25 V.A. 80% P.F.
Silicon steel.
Varying ratio.

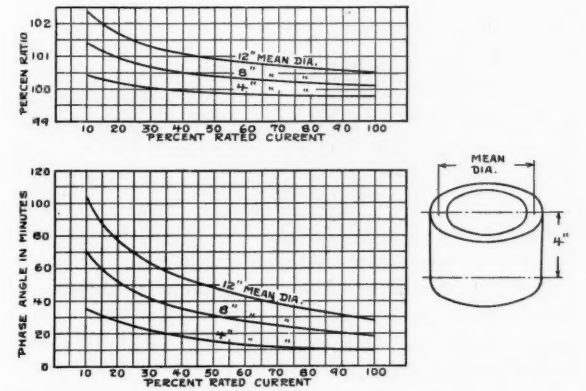


FIG. 7. RING TYPE CURRENT TRANSFORMER CHARACTERISTICS

Varying mean diameter.
Length ..... 4 in.
Gross area ..... 4 sq. in.
External burden, 25 V.A. 80% P.F.
Silicon steel.
Ratio, 800/5 amp.

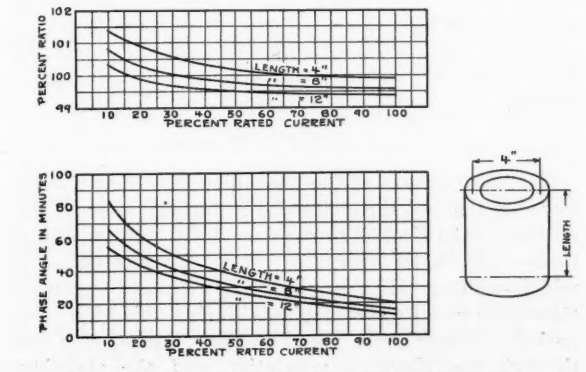


FIG. 8. RING TRANSFORMER CHARACTERISTICS

Mean diameter ..... 4 in.
Varying length.
Gross area ..... 4 sq. in.
External burden, 25 V.A. 80% P.F.
Silicon steel.
Ratio, 400/5 amp.

Figure 2 is a cross section of the transformer in Fig. 1 and shows the path of the leakage flux between the primary and secondary windings when current is flowing. A similar field, of course, exists between the lower parts of the coil, but the iron circuit holds this part of the coil so firmly that any trouble will develop first in the top side. Figure 3 is like Fig. 2 except that the flux lines are omitted and the resultant force is

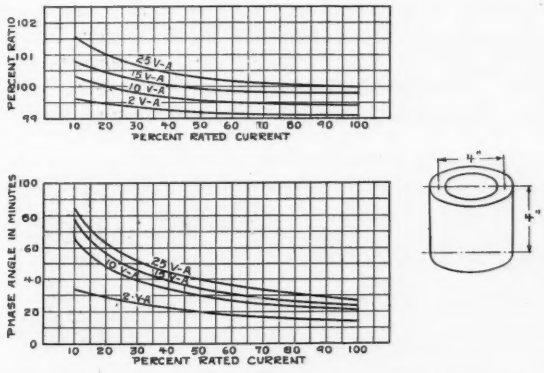


FIG. 9. RING TYPE TRANSFORMER CHARACTERISTICS

Mean diameter ..... 4 in.
Length ..... 4 in.
Gross area ..... 4 sq. in.
Varying burden.
Silicon steel.
Ratio, 400/5 amp.

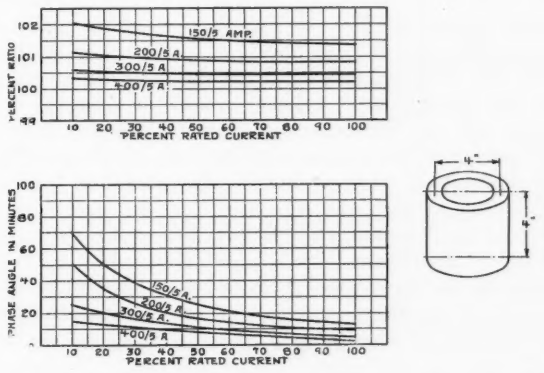


FIG. 10. RING TYPE TRANSFORMER CHARACTERISTICS

Mean diameter ..... 4 in.
Length ..... 4 in.
Gross area ..... 4 sq. in.
External burden, 10 V.A. 90% P.F.
High permeability alloy (Hipernik)
Varying ratio.

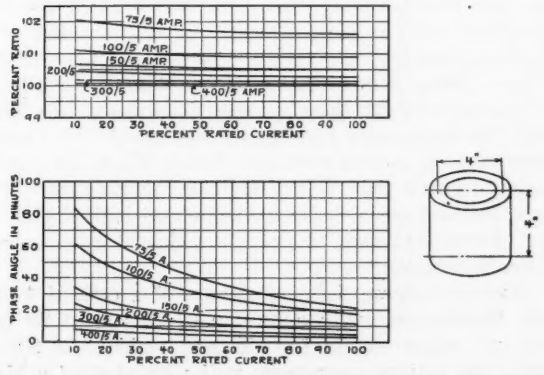


FIG. 11. RING TYPE TRANSFORMER CHARACTERISTICS

Mean diameter ..... 4 in.
Length ..... 4 in.
Gross area ..... 4 sq. in.
External burden, 2 V.A. 90% P.F.
Hipernik.
Varying ratio.

shown pushing the electrical centers of the two coils apart.

Figure 4 shows what happens if the electrical centers of the two coils do not lie in exactly the same plane. The force of the repulsion between the two coils has a component which tends to move the primary coil axially along the secondary. Occasionally a transformer is destroyed in this way.

In ring type current transformers, on the other hand, the forces between primary and secondary are nearly balanced within the transformer itself. Figure 5 shows this condition. The primary winding consists of a single conductor which passes through the center of the ring. The secondary winding passes around the ring

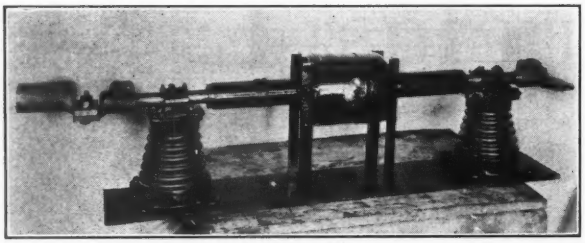


FIG. 12. INDOOR MOUNTING FOR RING TYPE TRANSFORMER

inside and outside. The secondary conductors inside the ring are repelled by the current in the primary conductor, since the current flows in the opposite direction, but the conductors outside the ring are attracted by the current in the primary conductor since the currents flow in the same direction. Since the outside secondary conductors are farther from the primary than the inside secondary conductors, the attraction is somewhat smaller than the repulsion, but the difference is carried by the iron core. This makes the ring type current transformer reliable mechanically for any kind of short circuit and many engineers value this feature so highly that they are willing to sacrifice something in performance to obtain it.

Characteristics of Various Designs

This brings us to the question of the performance of ring type current transformer. What can be expected of them and why? If the ratio is fairly large and if the diameter is fairly small, excellent performance can be obtained with a reasonably small burden but small ratio or large diameter or large burden will result in poorer performance. To give an idea of the effect of these various factors, Figs. 6 to 11 have been calculated. In all these curves, no attempt has been made to compensate the individual curves. The same compensation is used throughout each set because it is desired to show the effect of the varying quantity. If a particular curve is to be used, its position relative to the 100 per cent ratio line can be adjusted by changing the compensation.

Figure 6 shows the performance of a core of 4 per cent Silicon steel with a burden of 25 v.a. at 80 per cent p.f. when wound for different ratios. At 800/5 amp., the accuracy compares well with that of a high grade wound type transformer. At 400/5, the accuracy is not nearly so good and at 300/5, it would probably not be suitable for watthour meters.

Figure 7 shows the effect of enlarging the diameter of the ring. The ratio is 800/5 amp. and for the 4-in. diameter ring, the curve is the same as in Fig. 6. The ratio and phase angle grow higher as the diameter of the core increases.

Figure 8 shows the effect of a change in the length of the core. To show the improvement which is possible, we start with the 400/5 amp. curve of Fig. 6 and see the effect of doubling and tripling the length of the iron.

Figure 9 starts with the same 400/5 amp. curve and shows the effect of changing the burden. As the burden decreases, the curve grows flatter and flatter until at 2 v.a., which approximates a single watthour meter burden, an excellent performance is obtained.

Figure 10 shows the effect of building the core of high permeability nickel-iron alloy (Hipernik) instead of silicon steel. The burden this time is 10 v.a. and the performance is exceedingly good down to 200/5 amp. If the burden is still smaller, even lower ratios may be used. For 2 v.a., Fig. 11 shows the results. The ratio curve remains flat at 75/5 amp., but the phase angle has become rather high.

Figures 12 and 13 show two different ways of mounting ring type transformers for indoor service, and

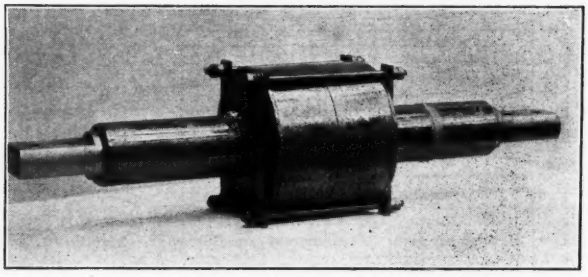


FIG. 13. ANOTHER TYPE OF INDOOR MOUNTING

in the illustration at the head of this article is shown an outdoor mounting.

To summarize, then, we may say that ring type current transformers are desirable because of their simplicity and their strength against short-circuit stresses. They can be made of Silicon steel to give good performance and reasonable size down to a ratio of about 400/5. Below this ratio, high permeability nickel-iron alloy can be used to build ring type transformers of still lower ratio. Ring type transformers can be mounted in a variety of ways and for either indoor or outdoor service.

Highest stages of the Mississippi River at Keokuk, Iowa, in the last three decades materially affected production of the Keokuk power dam and forced the Illinois Power and Light Corp. to throw the burden of its middle-western Illinois electricity demand upon its Galesburg and Powerton plants during this high water period. Power from the Powerton station was sent through the Kewanee substation and the Galesburg plant, which has been maintained only as an emergency unit, was pressed into service, producing about a third of the power required in the Galesburg community.

Electricity---What It Is and How It Acts*

PART XXIII. THE RELATION OF IONIZATION TO THE ELECTRIC ARC. THE THEORY OF THE DISRUPTIVE DISCHARGE. BY A. W. KRAMER

IF WE WERE TO CONTINUE our discussion of the three-electrode vacuum tube, we should be led, inevitably, into a detailed consideration of "radio" for it is in the radio field that the vacuum tube has received its greatest application. This, however, would take us ahead of our story. Radio is a wave phenomenon involving a familiarity with the principles of electromagnetic radiation and as these have not yet received treatment, it will be necessary to defer further consideration of the vacuum tube and its applications until certain other preliminary matters have been touched upon.

We still have more to learn about ionization. The reader who has thus far had the patience to follow this series may wonder occasionally why so much stress is given to the process of ionization—is it of such great importance?

Without ionization, we should know practically nothing of electricity, for ionization, as we have seen is the process whereby neutral atoms are broken up into positive and negative electrical components. Since it is the behavior of these components in attempting to establish neutralization that is responsible for all electrical phenomena, it will be evident that ionization is of exceedingly great importance.

Ionization, we have seen, plays an important role in the process of gaseous conduction and we have studied its action in quite some detail in the vacuum tube. Outside of the vacuum tube, perhaps the most interesting result of ionization in gases is the electric arc. The electric arc is of major importance in electrical engineering and was without doubt the first electrical phenomenon to be observed by man, for natural lightning is one form of the electric arc. While the electric arc has many useful applications, it also has destructive characteristics which have caused electrical engineers a great deal of worry.

ARC PHENOMENA ARE COMPLEX

Despite the seeming simplicity of an electric arc, it is very complex in nature and its behavior is often erratic. It is difficult to carry on consistent experiments with the arc. As Dr. Slepian[1] of the Westinghouse Company aptly puts it, "A very profound characteristic of the arc is its strong 'won't.' When the engineer tries to make a good automatic welding machine or a good arc lamp, he naturally wants the arc to burn smoothly and strongly but he is troubled because the arc wants to flicker and fuss and go out. On the other hand, when he tries to build a switch, then an arc forms at the contacts which burns steadfast and true."

An arc may be defined as a discharge of considerable current at comparatively low voltage in a gas or in air between electrodes. An ordinary gas, at atmospheric pressure and temperature, is a good insulator, being made up almost entirely of neutral atoms. These normal atoms, we know consist of equal positive and negative electrical charges, and exhibit no electrical effects of any kind. They may be considered as perfectly married couples, not given to "cutting loose." Among these neutral atoms, however, there are always present a number of free ions moving about at various velocities. These free ions do not possess the virtue of consistency as do those which make up the normal atoms. They have entered into a sort of companionate marriage arrangement in preference to the more orthodox arrangement of the normal atom. These move about, now staying awhile with one atomic system, then moving on to another. Occasionally two of them of opposite charges meet and form a neutral atom. Often, however, a fast moving negative ion or electron will collide with a neutral atom with such force as to disrupt

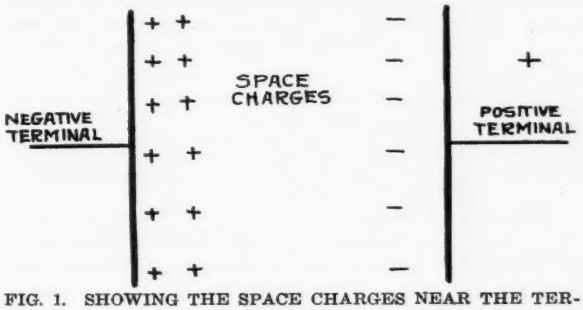


FIG. 1. SHOWING THE SPACE CHARGES NEAR THE TERMINALS OF AN IONIZED GAS SPACE

it. Such disruptions normally are balanced by the number of recombinations so the total number of free ions in a gas remains constant.

EFFECT OF ELECTRIC FIELD

When a voltage is applied across a gas, as in the case of an ordinary spark gap, the mean velocity of the free ions rises and more new ions are produced by collision but as long as the voltage remains moderate, only a minute current will flow. These newly formed ions, if the gradient continues to be maintained, may also generate more ions by collision. Thus, starting out with only a few charged particles in a gap, by the application of sufficiently high voltage great conductivity may be developed, and the current may rise to a large value. When this occurs, we have what is known as a luminous or disruptive discharge. This is the type of discharge that occurs when a solid insulator breaks down as described in Part X.[2] It is not quite clear at the present time whether the breakdown of a solid insulator is due to the pressure of gaseous ions in the solid material or to an actual breaking down under the electrostatic stress of the neutral atoms.

Thus, the formation of an electric arc or spark by merely impressing a high potential across a pair of electrodes is caused by ionization by collision. The

*All rights reserved.

[1]Theory of the Electric Arc. Journal, Western Soc. of Eng., April, 1928.

[2]October 1, 1928 issue, page 1041.

entire phenomenon, therefore, hinges upon the fact that all gases at ordinary temperature and pressure contain a small number of free ions. If there were no free ions in the gas to begin with, there would be none to accelerate by means of the field and no matter how long the voltage was maintained, no current could flow. Of course, it is conceivable that if the voltage were raised sufficiently high, the neutral atoms themselves would be strained to a rupturing point and thus ions would be produced. The voltage necessary to rupture a neutral atom in this manner is greatly in excess of that ordinarily required to cause a discharge in a gas,

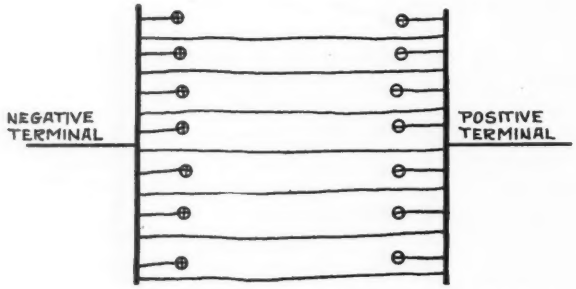


FIG. 2. DIAGRAM SHOWING HOW THE LINES OF FORCE EMANATING FROM THE TERMINALS, TERMINATE ON THE SPACE CHARGES

so in the consideration of arc phenomenon, this action need receive no consideration.

Proof That the Arc Is Due to Pressure of Ions

That the formation of an arc by the breaking down of the insulating qualities of a gas is due to ions existing initially in the gas can be demonstrated effectively by shielding the gas from all possible sources of ionization.

The ions existing initially in ordinary gases are produced by a number of agencies. Research has shown that gases can be ionized by means of x-rays or ultra-violet light or by the rays of radium. When a beam of x-rays is passed through a gas consisting of neutral atoms, some of the atoms will be ionized. The reason for this will be discussed in subsequent articles in the consideration of radiation. Similarly, ultra-violet light will cause ionization and the rays from radium are very potent in this respect.

In the atmosphere surrounding the earth, all of these three types of radiation are present to a certain extent. The radiation coming from the sun is composed not only of visible light, but also ultra-violet and other short wave radiation. Recently Millikan has shown, by experiments in the high Andes, that other penetrating radiation is coming to us from all points of space. With all these rays acting on the atmosphere, it is natural that the gases of the atmosphere should be ionized. Since the earth contains comparatively large quantities of radium and other radio-active material, rays capable of ionizing gases are also issuing from the earth. From this, it will be apparent that it would be difficult to isolate a gas so that none of these ionizing agencies could act on it.

It has been shown, however, that by merely enclosing a spark gap in a dark chamber, thus shielding it from the effect of ultra violet rays, the initial ionization can be reduced to so small a value, that the time for ionization to build up may become quite large. Townsend,[3] in investigating this, found that when a gap was enclosed in a dark chamber for some time before applying a voltage, a voltage in excess of the normal breakdown voltage could be applied for several seconds before breakdown occurred.

The Disruptive Discharge

Thus far, although it was our intention to study the electric arc, we have in reality considered only the disruptive discharge which must occur before a true arc can form. A true arc is a discharge characterized by a low resistance as compared to that of the disruptive discharge. Of course, an arc can be formed in another manner without being preceded by the disruptive discharge, that is, when a circuit carrying current is opened by separating a pair of contacts, but this method of forming an arc will be considered later.

The disruptive discharge may take a variety of forms. It may occur in the form of a spark, or as a uniform glow or as a brush discharge, the form depending upon the form of the electrodes and the pressure of the gas. At ordinary pressures if the electrostatic field is uniform between the electrodes, conduction will take

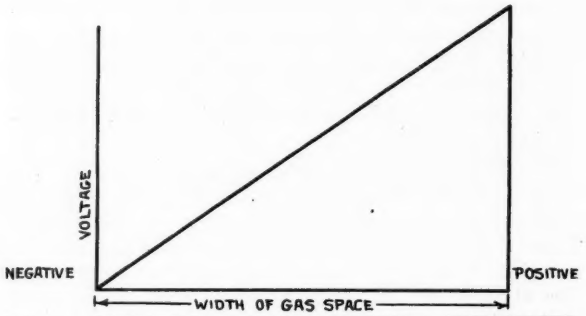


FIG. 3. POTENTIAL GRADIENT ACROSS A NON-IONIZED GAS SPACE

place in the form of a spark. If the field is relatively intense near an electrode, however, the gas in that region is disrupted, before that in other portions of the space between electrodes, resulting in a local glow which is known as the corona.

The disruptive condition is due mainly to ionization throughout the gas, the electrodes having only a secondary effect. The gas molecules have two effects: first they furnish the ions which carry the current; and secondly, they impede the motion of these ions. At low pressures, or with small distances between electrodes, the first effect is predominent, hence, the disruptive voltage (per unit of distance) increases with falling pressure, or with decreasing distance between electrodes as the molecules to be ionized become fewer. At high pressures, or with large distances between electrodes, on the other hand, the impeding effect of the molecules is predominant, hence, the disruptive voltage increases nearly in proportion to the pressure and the distance between electrodes.

From this, it is evident that the disruptive voltage is a function of the product of the distance between electrodes and the density of the gas. It has been found to have a minimum value between 300 and 400 v. occur-

[3]Conduction in gases.

ring at a pressure of 1 mm. of mercury for 10 cm. between electrodes.[4]

At extremely close distances between terminals, the breakdown voltage may be very high. Ordinarily, in air at ordinary pressures and distances of a centimeter or more, the breakdown voltage is about 30,000 v. per in. At extremely close distances, the breakdown potential may be 1,000,000 v. The reason for this lies in the fact that when the distance between terminals is very small, the distance through which the ions in the gas can move under the action of the field is too small to enable them to gather sufficient velocity to ionize other atoms by collision. As a consequence, with distances of this order, only under the most extreme potential gradients, (1,000,000 v. per inch or more) can the ions accelerate rapidly enough to gain the velocity required to effect ionization by collision.

Space Charge

In our previous discussion of the vacuum tube, we referred to the phenomenon of space charge. In the formation of an arc or disruptive discharge, the effect space charge is also made manifest.

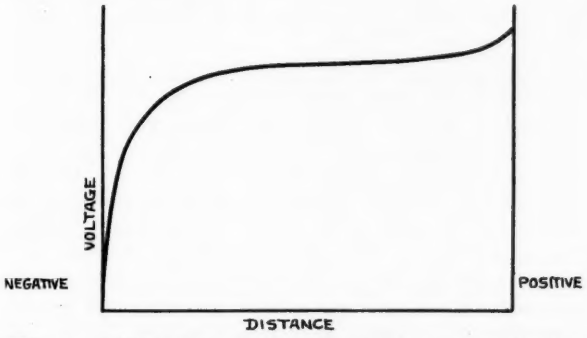


FIG. 4. POTENTIAL GRADIENT ACROSS A STRONGLY IONIZED GAS SPACE

NOTE: Practically all of the voltage becomes concentrated on the space charge.

Suppose we consider the effect of an electric field upon an ionized gas. Negative ions move toward the positive terminal or anode while positive ions move toward the negative terminal or cathode. In the center of the space between terminals, electrons move out toward the anode on one side but as many enter it on the other; therefore the number of electrons in that region remains practically constant. The same is true of the positive ions—as many move out toward the cathode as move in from the other side, hence the total number remains the same.

Close to the terminals, a different action takes place, however. In the space very close to the cathode, for instance, electrons move out toward the positive terminal but no electrons can move into it from the cold cathode. Thus, since electrons are going out and none coming in, this space will be left with a deficiency of electrons and an excess of positive ions, causing this space (close to the cathode) to assume a positive charge.

In the space close to the anode, a similar action takes place. Here positive ions are moving out but none are entering it from the anode, hence this region becomes negatively charged. Thus, we have a positive space charge at the cathode and a negative space charge at the anode.

Now, what is the effect of these space charges? The effect is the same as that of the space charge in a vacuum tube—it results in a distortion of the electric field. Ordinarily, with the space charges, the potential gradient would be uniform and would take the form of a straight sloping line as shown in Fig. 3. In the presence of the space charges, however, many of the lines of force which leave one of the terminals do not reach the other side. They terminate on the space charge. Therefore, we shall have a greater number of lines of force at the cathode or anode than we have in the center; hence, the field may be considerably stronger at the cathode or anode than it is farther out in the gas space. The voltage tends to concentrate next to the electrodes.

From this, it will be evident that the voltage across an arc or an extremely ionized gas space is divided up into three parts: the cathode drop, the anode drop and the drop in the central portion of the arc space. These facts regarding the arc and the disruptive discharge, while interesting enough from a purely academic standpoint, play an important part in all arc phenomena and it is necessary to understand them if we are to have a clear conception of what really happens in the electric arc. Further aspects of the arc will be discussed in the next article.

[4]L. A. Hazeltine, Electrical Engineering, p. 283.

Power Plant Fuels Range From Wood to Anthracite

OF THE SOLID fuels used in power plants, wood is the oldest although now used only in isolated districts or as refuse from sawmills. The moisture content varies from a few per cent in kiln-dried woods to about 50 per cent in undried timber, poplar being one of the highest. The calorific content varies from 6000 to 9000 B.t.u. per lb. and it requires, on an average, about 6 lb. or 75 cu. ft. of air per pound for combustion.

Peat is the first step in the formation of coal. The moisture content is high even when dried and about one-third of its available heat is used in evaporating the moisture. Washed and dried, it finds considerable use for domestic service.

Lignite or brown coal is the lowest grade of fuel mined in this country and is being used to a considerable extent in this country and in Germany for power plant use both on stokers and in pulverized form. The moisture and ash content is high, the heating value low and it has to be stored carefully to avoid spontaneous combustion.

Anthracite is the hardest, most lustrous and densest of coals, the specific gravity ranging up to 1.75. Because of its scarcity, it is now seldom used in power plants except from the waste piles as culm.

Bituminous coals, of which there are many grades, are the most widely used for power plant service. The volatile content ranges from 30 to 40 per cent, ash and moisture are low and heating values high. Three varieties known are the non-caking, caking, and long flame are used, the character of the coal depending largely upon the field in which it is mined.

Wrong Purchasing Methods Cost Money

ATTEMPTS TO FORCE PRICES BELOW THE SELLER'S ECONOMIC LIMIT, AS NARRATED HERE, OFTEN DEFEAT THEIR OWN ENDS. BY S. J. PENCARTER

IT WAS A frightfully cold morning in February, snowing and blowing, when I stumbled out of the sleeper at about 5:30, blunderingly grabbed my handbag, brief cases and envelope full of blueprints and waited on the open platform for the Squantumville local to happen along. Decent people are still in bed at that hour, but such a morning is merely one of the common things that a salesman gets used to after a while on the road. I particularly loathed this trip, not only because I had been married just a short time and had to leave the Mrs. and the baby at home, the latter not being well, but especially because I had been sent out to sell one of the toughest propositions that ever had Purchasing Agent painted on his office door. Even my sales manager at the office regretted the trip but someone had to go. I was in a mood that fitted me to sell gold dollars at about 25, 15, 10 and 5 per cent off list price, with 2 per cent for 10 days.

After I did get on the aforesaid local, same being ten minutes late, with cold cars 'n' everything, I bundled up in my overcoat as snugly as I could and dozed off for another 30 min., with a curious prejudice in my mind against our splendid railroad system, where just as soon as one gets off the main line flyers, he gets all the conveniences of Siberian railroads. After a warm breakfast and a sprucing-up at the hotel, however, I felt more charitable and more like selling the above gold dollar at cost, plus overhead and a reasonable profit.

THE AUCTION PINOCHLE BEGINS

Mr. Jones of the International Co. (both names fictitious) never got in until about nine and took another hour to digest his morning mail. Then he would be ready for us, we were usually told, and when I say us, it usually meant every firm in our line who could afford to send a representative up there. We were each called into his office, beamed our great pleasure, presented our proposition in 30 min. and left then until 2:00 p. m. That enabled us to give our price and describe what we offered. Usually we all met in the hotel lobby before going to see Mr. Jones and greeted each other like Christians, for most of the chaps on the road in each line know one another and, having similar problems, soon get on a more or less friendly footing. Until 2:00 p. m. we were practically free to see other prospects in the vicinity. But at the zero hour, we were all called into a large conference room and the proposal of each was read, with his price and guarantees. You can imagine how you would feel, not being used to business methods like that but we are more or less hardened to it.

Then begins the haggling. Mr. Jones sits in the center and the rest of us all around the large table. As the bids are read off, we scribble down each man's price and see about where we dangle. Some men will start cutting their prices right there and then. Others will say they will have to consider the matter and call the home office by long distance, so after some cutting of prices and raising of guarantees, we go out again, to come back at 4:30. In the meantime, some of us will have called our home office and secured authority to cut our prices and learned at what minimum price they will take the business.

Auction pinochle? You bet! Nothing else and the lowest man always gets the job and at the highest guarantees of the entire assembly. At 4:30 we all get in again with our new low prices and our new higher guarantees, if we were allowed to raise them. Now the new prices and guarantees are read off. By watching this process we can see how badly somebody wants the job and is willing to risk loss. Now more haggling, until finally we are all asked in turn our best price and guarantees. That done, Mr. Jones closes his books and asks each to leave his hotel address so he can be called by phone. Nobody knows anything definite yet, except who is the lowest bidder.

Having gone to our hotel—usually there is one selected by the sales fraternity in each city or town—the secret bidding starts. Of course, you know, Mr. Jones is busy but will be glad to talk over the phone "if anything important should arise." I'll bet Mr. Jones hangs over the phone for half of the night talking to some of the gang at the hotel. If you don't call him, be assured that he will call you to be sure that you have put in your final word. Each price is final until further revised. If ordinary persuasion does not work, he will say that he'd like to give you a chance but he just can't see that price. Well, those who give up in disgust usually dig out and go away on further business and somebody gets stuck with the lowest price and highest guarantee.

WHAT A PRICE CUT REALLY IS

Now don't get all red in the face and tell me that jobs sold that way are the rare exception. It is a disgrace to modern sales work that bidders will stand for anything like that. But my great surprise on the trip to Mr. Jones was that I was given the job after only cutting my price 20 per cent but that cut, while seeming large, was made after we had first added 25 per cent to the price we really wanted the work for, before I had left the home office! Just why I got the job at that figure is too long to go into in detail but I found later we were given preference principally on account of our ability to make quick delivery, as we had the proper size in stock.

If the laws of economics mean anything, they mean that one cannot buy at lower than cost, plus a profit sufficient to stay in business. The bidder who sells at less will surely be wiped off the face of the earth if he should persist in defiance of his bankers. That much being true, the bidders will see how close they can run to the danger line without getting burned, until they have been rather painfully burned and, with repentance, have acknowledged the Great Law that business must

worship faithfully. Any purchasing agent, therefore, who expects to get something valuable for less than its fair worth is due for reprisals in a number of forms.

A friend of mine, in the same line, recently inherited unexpectedly enough money to put him on easy street for the balance of his days. Before he left his firm, he begged to be allowed to go on a certain job, which the firm felt they would never get anyhow. With the accumulations of 15 yr. of road work and recollections of other Mr. Joneses in his mind, he got hold of the man privately before the interviews were granted and started in on him. We will call him Mr. Doe.

"Mr. Doe," the salesman began, "Is this going to be another auction sale like all the others you have pulled?" Mr. Doe smirked a weak smirk.

"Listen, Mr. Doe," continued the salesman, "I want to tell you something you apparently have not yet unearthed. The whole gang has just met in the hotel lobby and discussed the matter as usual. Each man has added amounts varying from 25 to 40 per cent to his bid, knowing you from years back. When you get these price cuts, please realize that they are fictitious. We can't sell below cost and stay in business. We all have our price when we leave the home office and we know from past performances just what to tack on. Now, if you want to get real prices, tell each of the boys that there will be one price received and but one opportunity to put in a price. Some of them will probably faint but you try it and see how you come out."

Mr. Doe promptly blew up with all on board. The usual warm gray-blue in his eyes turned to cold blue-gray. "Probably you're not telling me how to run my business, are you?" he exploded, with vain efforts at self mastery.

How Mr. Doe Was Given the "Low-Down"

"No, brother Doe," calmly went on the salesman, "I'm telling you in other terms that you are paying for these tricks and that you are also paying more than others for the same stuff. Now, if you please, I'll show you a few figures—" he rapidly paged over a small memo book and said: "Hopeville Electric bought the following——" showing Doe the list, "and they got it for $32,678 on one price. You may recall that you paid last May just exactly 7 per cent more than they did for nearly the same stuff. And if you want to do it, go back in your files and see what you have paid for equipment during the last two or three years. You will see that you always paid more than others because we bandits of the road have you catalogued and we know what we have to do to get away with you and not get burned."

Mr. Doe was certainly on the fence. He might have eaten the salesman up, but as he didn't care for meat he slowly passed from the stage of anger to the one of general doubt and disgust, somewhat similar to the feeling one gets after smoking a very strong cigar.

Mr. Doe did not at all relish the idea of the news getting out that, in spite of alleged shrewd methods, he was paying more for his supplies than the despised bunch down at Hopeville. Making a hasty peace seemed to be the best move; meanwhile he could consider other measures.

"Well," he began, "I am never averse to new methods, even though they may cause trouble in the end—just to prove what is the best course to follow. I can't say now definitely that we will make any change but will at least give it consideration. In the meantime, may I be sure of your discretion in the matter?"

"Surely," declared the salesman, "go to it and think it over."

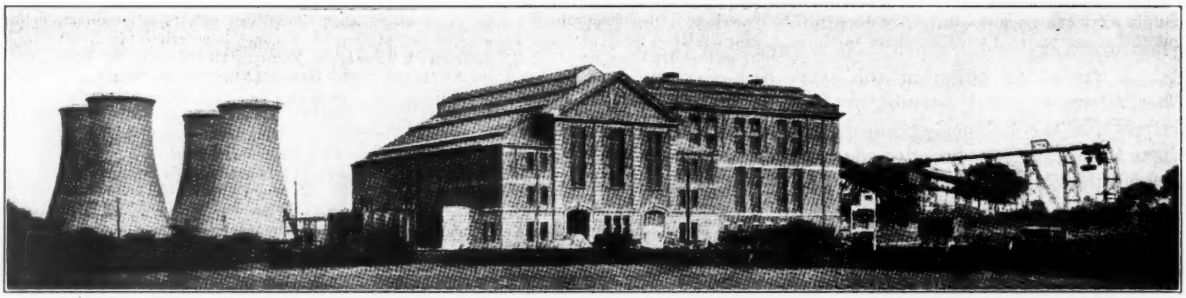
So Mr. Doe Thought It Over

True to his word, Mr. Doe thought it over and by the time the interviews were granted no trace of the battle remained on his clean-shaven face. The first man in was Barney Higgins, who entered with his usual smile and fat cigar. What occurred while he was in there will never be proclaimed in print but we all know he went in with his usual "lamb to the slaughter" wisecrack and came out pale, no cigar, and beads of cold sweat on his forehead. And Barney kept right on going, too, probably in search of stimulants. By the time our salesman's turn came around, he knew that the idea of one price and one time to put in a price had worked. Doe was smiling and extremely sociable and passed out a cigar. Outside of the routine description of offerings, nothing startling happened except that it was announced that each man was to put in one price and that was to be final. Wow!

I am told that Mr. Doe got his equipment lower than at any other letting of work and has not since deviated from the one price policy. This policy is in line with the best public contract lettings and has amply justified itself. Moreover, it is clean business.

Only business methods that will stand close scrutiny should be allowed in the purchase of power equipment. Every now and then we hear of some executive, who has been accepting confidential commissions, packing up and moving out. The whole tone of business has changed and the methods of a past age are going fast. Every executive who accepts commissions is sitting on a stick of dynamite, for he may rest assured that the supply houses have him catalogued and that his price is common property among the sales fraternity. In many cases, this practice is the only one that will put across an inferior product and as soon as the buyer gives his patronage to another house, the taker of confidential commissions is in more danger than ever.

Problems of profitable rural electrification, merchandising and operating economies occupied 350 members of the Iowa section of the National Electric Light Association at its recent annual convention. Nearly a score of utilities' plant managers participated in the symposium of rural power extension, which is commanding greater attention in Iowa than ever before. The power companies, it was stated, have the power available but the problem is in supplying it at a rate which the farmer can afford to pay and at which the company can show a reasonable operating profit. The cost of service to a farmer is much greater than in the city, where there are 50 customers to mile, while in the rural communities the average is less than three to a mile. Transmission costs represent the greater item in rural service and the most feasible solution was recommendation of a program through which the farmer can find greater use for electrical energy for actual work on the farm if he is to use electricity profitably.



Longford Station Has Unique Features

COVENTRY (ENG.) CORP. ADOPTS NEW DESIGN OF COOLING TOWERS, AUTOMATIC EVAPORATOR CONTROL AND SENSITIVE TURBINE GOVERNOR DESIGN

CENTRAL ENGLAND has unfavorable conditions for cooling water supply, hence, cooling towers are essential in a condensing plant. Feedwater, too, must be conserved and the makeup carefully restricted, also the quality of the water makes evaporators desirable where boilers are to be operated at high output. Close regulation is always sought, in this case by using an oil-operated pilot valve to the servo motor which operates the nozzle valves. Effective coal handling is always important and, in this plant has been so provided that both barge and rail coal may be moved simultaneously either to bunkers or emergency storage.

General Plan Provides for Expansion

As seen in the headpiece, the building is of pleasing design, with inconspicuous stacks, due to the use of induced draft. Located on the Oxford canal, coal may be delivered by barge to the far side of the canal, where the overhead track is seen, and brought across to the storage or bunkers by a conveyor bridge; or it may come by train on the near side and be dumped by a car tipper to a clearing chamber, thence conveyed to storage.

At the left are the unusual looking cooling towers. Transformer cells are along the nearer side of the building which houses switching equipment, condensers, evaporators and generating units. The boiler house extends to the rear, toward the coal storage and conveyors. The plant may be enlarged in 40,000-kw. units, each having two 20,000-kw. generators and eight boilers to evaporate 60,000 lb. of steam an hour, 325 lb. and 700 deg. F. with provision for 25 per cent overload. Present construction is the first unit except that the circulating water system is for the entire ultimate 100,000 kw. capacity.

Coal and Ash Handling

Barge coal is unloaded at a wharf by grab buckets running on an overhead rail seen at the right of the headpiece illustration. It is discharged into an automatic weigher, which records each load, also total weight, then taken by an inclined bucket conveyor across the canal to boiler-house bunkers or to chutes which deliver to the 3500-t. storage yard.

Rail coal is weighed in cars then delivered to storage by a car tipper. Trimming in storage, also reclaiming from storage to the bucket conveyors is by means of a 3½-t. jib crane running on a track down the middle of the yard.

Ashes are dumped from the hoppers into a conveyor which quenches them and carries them to storage bins outside the boiler house.

Thence they go to carts, or to a ropeway bucket system for transfer to marsh land at some distance from the plant, the ropeway buckets passing beneath the ash bin hoppers.

Boilers and Accessories

Eight Tridrum Stirling boilers are set in rows of four, each one of 60,000-lb. steam an hour capacity. Each boiler has, superheater, Green economizer, chain-grate stokers, Diamond sort blowers, Sirocco induced draft fan and grit arrester. Steam is generated at 325 lb. pressure and 700 deg. F. with feedwater from the economizer at 300 deg.

Dimensions of the equipment are: Each boiler, 9594 sq. ft. heating surface, 50 per cent of which faces the fire; stoker 9 by 17 ft., 306 sq. ft. grate surface; superheater, 2140 sq. ft. heating surface; economizer, tri-tube, three-pass for gases, with 6647 sq. ft. of surface taking water at 200 deg. and discharging at 300 deg.; fan 55 in. diameter at 575 r.p.m.

Boiler control is from an instrument panel in front of each boiler, which shows temperature and draft for all important points in boiler and economizer, shows and records flue condition and has a Bailey air and steam flow meter for control of steam-air ratio.

Turbines and Condensers

Each main 21-stage turbine has an impulse high-pressure end with double-flow low-pressure end and is served by a spring-supported condenser with 22,000 sq. ft. of surface. High and low-pressure ends are connected by flexible piping as seen in Fig. 1.

Governing is by several valves and nozzles, to give high efficiency. Oil pressure moves the pilot valve which admits oil to the servo motor operating a nozzle valve, thus reducing the work done by the governor and securing rapid operation. Tests show that it is possible to open and close 12 nozzle valves in 1.34 sec. Maximum continuous rating is reached at 28 in. vacuum without bypassing but, for temporary overload, low steam pres-

FIG.

sure or poor vacuum, high-pressure steam can be admitted to the lower stages of the high-pressure end. At 10 per cent overspeed or if the oil supply fails, the emergency stop valve is closed automatically by oil pressure.

For circulating water, 33-in. steel pipes are laid in a concrete trench 10 by 10 ft. to the cooling towers and return is to a reinforced concrete culvert 850 ft. long, 8 ft. wide and 10 ft. deep from which suction is taken to all condensers. Make-up circulating water is taken from the canal and a 22-in. discharge pipe into the canal permits of emptying the system or circulating water to prevent freezing of the canal.

Cooling towers are of reinforced concrete of hyperbolic shape, as seen in the headpiece, with natural circulation through triangular openings all around the bases and a venturi tube effect at the top to reduce discharge air velocity and prevent loss of water. Cooling water comes to the top through a central vertical pipe and flows to radial troughs. Inclined retarding boards cause the water to work toward the outside of the tower where the air is cooler.

Normal capacity of each tower, which is 100 ft. diam. at the base by nearly 100 ft. high, is 528,000 gal. per hr. cooled 17 deg. F. but satisfactory operation is secured through a range of 300,000 to 1,250,000 gal. per hr.

Condensate is metered and any make-up feedwater needed is taken from the circulating water pipes and passed through an evaporator to the low-pressure heater, thence to a storage tank. When needed, it is sprayed into the upper part of the condenser so that its air is removed by the ejectors.

Feedwater Is Stage Heated

Condensate from the condenser and heater drains is discharged from the condensate pump to the low-pressure heater. This takes steam from the turbine, from the evaporator or from both and has 750 sq ft. surface. Thence the water goes to the high-pressure heater, with 300 sq. ft. of surface, using pump exhaust at 3 lb. pressure. Water at 200 deg. then goes to the feed pump or to a surge tank, the entire system being sealed air tight. The feed pump discharges through the economizer to the feed lines.

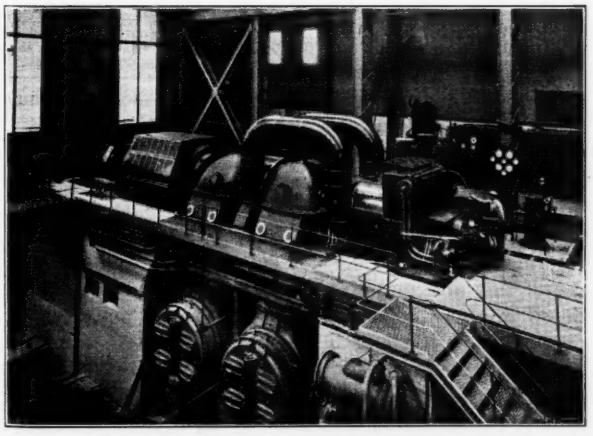


FIG. 1. TURBINE WITH CONDENSER DIRECTLY BELOW

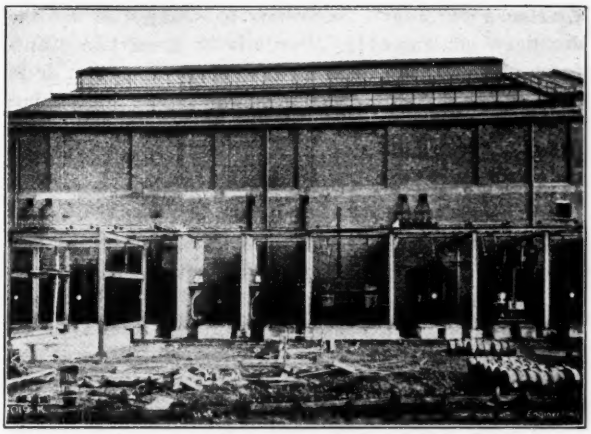


FIG. 2. TRANSFORMERS ARE MOUNTED IN OUTDOOR CELLS

To supply make-up feed, a vertical, single-effect evaporator is provided, with capacity of 7500 lb. of raw water an hour, taking bled steam from either of two points in the main turbine according to the load. Vapor from the raw water is carried to the low-pressure heater and mixes with that extracted from the turbine, passing through the condensate pump to surge and storage tanks, each of 3000 gal.

If feedwater demand is more than the condensate, level in the surge tank falls and a float valve opens to allow water from the storage tank to pass to the spray inlet of the condenser. As the level in the storage tank falls, a float opens a butterfly valve to supply steam to the evaporator and make-up is delivered to the condensate pump, thence to the surge tank, until its level is restored, so that make-up to the condenser is shut off. The evaporator continues in operation until surplus flowing from the surge tank to the storage has restored the level in the latter; then the evaporator steam valve is closed by the storage-tank float.

Electrical System

Generation of main current is at 6600 v. and 50 cycles per second, three-phase. Connection is solid to a bank of three main transformers, seen at the sides in Fig. 2, stepping up to 33,000 v., at which voltage all switching is done.

Auxiliary current is at 420 v. from a 714-kv-a. machine. Excitation for the main generator is from a 60-kw. exciter whose field, in turn, is supplied from a 13.5-kw. machine which also excites the auxiliary a.c. generator. Tirrill regulation controls the auxiliary exciter to keep the main generator voltage constant while a hand-operated rheostat is used in the auxiliary a.c. generator field circuit. Switching control is on panels in a gallery at one side of the turbine room, the actual switch gear being in a closed compartment above. Dummy indicating circuits are provided above the panel boards. Usual provision is made of interlocking mechanism and potential transformers which are rendered inaccessible so long as their circuits are alive.

Main circuit breakers are oil-filled, with three phases in one tank, separated by insulated metal barriers. The capacity of each is 500,000 kv-a. at 33,000 v. Provision is made for gas expansion and relief of overpressure.

House current is from bus bars supplied by the auxiliary generator or, alternatively from two transformers, 33,000 to 420 v. for emergency operation or to start up from the transmission line if the station has been shut down.

Lighting, switch gear control and battery charging are from two 62.5-kv-a., 420 to 190-v. transformers with motor generators supplying 110 and 170 v. d.c.

Main and auxiliary transformers are placed in outdoor cells as shown in Fig. 2 with equipment for testing, treating and conditioning the oil. Air jet cooling is used, these being among the largest of that type installed in England. Four-part distributed cores are used with high-tension coils of continuous disc type and inside these low-tension coils of helical type with several conductors in parallel. Adjustable coil-clamping structures give uniform support and minimum distance between supports. The construction aids in oil circulation, facilitates cooling and eliminates hot spots.

Main transformers are mounted on carriages with rollers and draw eyes so that any one can be easily removed and replaced by a spare which is kept in the turbine room.

For data and illustrations on this plant, we are indebted to Engineering of London, England, which published an article having plan and elevation drawings for which space is not available.

Practical Methods of Oxy-Acetylene Welding

PART II.* PREPARATION OF PARTS FOR WELDING; USE OF FLUX; WELDING OF STEEL, WROUGHT IRON, COPPER AND ALUMINUM. BY L. A. COWLES

USUALLY DIRECTIONS come with the torch but a good rule to follow is: Use the tip which maintains a pool of molten metal having about the same diameter as the thickness of the piece to be welded with as low a gas pressure as possible without the torch popping.

Flame adjustment is simple but extremely important. The torch is lighted by turning on the acetylene. A bright, smoky flame is noticed but as oxygen is added the smoke disappears and an indefinite shaped cone can be seen at the tip. Two points of the cone can be seen, one beyond the other, and as oxygen is added they merge into one clearly defined core of blue flame. More oxygen will cause the flame to sputter or roar and the cone will become ragged. A clearcut cone just verging on a slight excess of acetylene is desired. The hottest part of the flame is at the tip of the cone but holding the tip against the work will oxidize the metal.

WELDING

Some manipulation of the torch is necessary to distribute heat evenly on each side and throughout the joints. The filler rod is used to puddle the metal, working the oxide out while adding material and flux as needed. To go farther with the work, we shall have to consider preparation of the parts, flux and filler rods.

PREPARATION OF THE PARTS

The parts must be clean, the presence of grease or oil is especially to be avoided. Except when welding real thin pieces, the metal must be veed out, making it possible to secure fusion clear through the piece. If the metal is extremely thick, it may have to be veed out and welded on both sides. The thicker the piece the wider the vee needed. The preparation of the parts boils down to cleaning, veeing out and lining up. Carbon blocks or carbon paste is useful for lining up, as the carbon does not burn, spall or chill the metal.

If the parts are cast iron, the line of fusion long or intricate, it will be necessary to preheat, i.e., after lining up, a furnace of brick is built around the work and the metal heated with a charcoal or gas flame. The heating must progress slowly and a uniform temperature should be maintained. No rules can be given to govern preheating work as the temperature will vary with the metal. Too high a temperature may warp a casting or too low heat may cause contraction strains and even cracks may develop. Slow cooling is as important as preheating. The castings should be covered with asbestos and in the case of a large casting, reheated after completing the weld in order to minimize the contraction strains. Steel is not so difficult in respect to contraction strains but, if convenient, covering the work with asbestos until cool will improve the quality of the weld. The fact that the metal in the weld will be cast steel must be taken into consideration and the weld reenforced or built up to assure the strength necessary. Cast iron differs somewhat in this respect as a good weld is often stronger than the original metal.

FLUX

The affinity which molten metal has for oxygen is illustrated by heating a piece of steel and noting the scale (oxide of iron) formed. This is caused by the combination of oxygen with iron forming iron oxide, comparable to rust. The formation of rust is accelerated by heat and a few seconds with the metal in a molten condition will cause the formation of as much rust as would years of exposure to the atmosphere.

In order to correct this, preventing the formation of oxide, a flux is used which has a chemical property under high temperatures which breaks up the oxide into its component parts.

Oxide formed in cast-iron welding is lighter than the molten metal and floats to the top, making it easy to dispose of. This oxide can be seen and by judicious use of flux and puddling with the filler rod can be reduced to a minimum.

I do not recommend the use of home-made flux, although excellent results can be obtained by mixing equal parts of carbonate of soda and bicarbonate of soda. The manufactured flux is the best as it is uniform in quality and less of it will be required.

*Part I of this article appeared in the April 15, 1929 issue of Power Plant Engineering, page 482.

You will notice that upon the application of the flux, the molten metal will become clear and mirror-like. It will seem to melt more easily. The union of the metal in the weld and the metal added with the filler rod is almost instantaneous.

Nobody should attempt to weld cast iron without using flux. The flux should be applied with the rod.

Steel and Wrought Iron

Flux is not essential in welding these metals although there is some oxide formed and a small amount of cast-iron flux will be beneficial.

The oxide in this case, as with cast iron, has a higher melting point than the molten metal and although the oxide has a tendency to float, steel and wrought iron sets so quickly that more oxide is likely to remain in the weld. A small amount of flux will remedy this to some extent.

Although the burning of steel is the principal thing to guard against, which is particularly true in adding metal from the filler rod, there is slight danger of burning wrought iron, in fact, it may be doubted whether it can be burned at all. In the case of both metals, however, the filling rod must be protected by proper application of the rod and careful manipulation of the torch. The correct method is to add metal by holding the rod in the molten pool, being careful to keep the tip of the flame out of direct contact with the rod, as this will burn it.

Flux will not prevent the formation of hard spots, nor will it remedy difficulties encountered due to neglecting to clean the parts properly. Hard spots which make the weld difficult to machine are caused by chilling of the metal when brought in contact with the comparatively cold surface upon joining the old and new metal. This can be prevented by melting the old into the new metal.

Copper Welding

Copper is difficult to weld because of its affinity for gases when melted. Oxygen produces oxide of copper which makes the weld brittle and any occluded gases leave the metal full of blow holes.

The flux used must have a greater affinity for oxygen than copper and no more should be used than needed as any excess is detrimental to the weld. For this reason the flux is incorporated in the welding rod (phosphorus).

Copper should not be melted without adding metal with the filler rod if for no other reason than the phosphorus necessary to prevent the formation of oxide.

In welding copper alloys a flux is used. If it were possible to determine the alloy the flux would be varied to suit the conditions but as this is not possible a flux averaging the requirements is used, and a welding rod used most suited to the alloy. Borax, melted and then powdered, makes an excellent flux but the author recommends the manufactured article.

Repairs of Aluminum

Repairs of aluminum are seldom met with by engineers and directions for welding would take up too much space, although a few pertinent facts no doubt would be interesting. Aluminum, when melted, oxidizes freely. The oxide is chemically inert and difficult to dispose of with flux. Puddling or working out of the oxide with a puddle rod is resorted to in addition to the use of flux.

Welding Rods for Cast Iron

Ordinary cast iron used as filling material will produce white iron, which is hard and cannot be machined. Nor can one secure good cast-iron rods from any foundry not making a specialty of this material. The author recommends the use of the best grade of filler rods for all work. This reduces the gas consumption, speeds up the work and results in satisfactory welds. Cast-iron rods are made up in sizes from $\frac{3}{16}$ to $\frac{1}{2}$ in.

Welding Rods for Steel

Instead of going into detail, a general rule for the filler rod to use with steel can be given: Use the rod mostly nearly like the metal to be welded.

Mild steel is the easiest to weld, the difficulty increasing with the carbon content. Cast-iron flux should be used on steels of high carbon content and if the same hardness is wanted in the weld a welding rod of high carbon content should be used. It is advisable to become a good welder of mild steel before attempting the welding of high carbon steel.

Miscellaneous

In making repairs on brass and bronze, tobin bronze or brass is used for the welding rod and flux is always necessary.

Galvanized iron presents no difficulty as the galvanizing burns off and then the clean iron can be welded.

German silver, nickel and white metal may be considered unweldable.

Lead can be welded by the oxy-acetylene flame but the temperature of this flame is too high for general use. Oxy-hydrogen is better adapted to lead welding.

Bonds between different metals are usually made by brazing, i. e., using bronze or copper welding rods. Bronze flux is used.

Results of capital expenditures of the Central Illinois Light Co., Peoria, Ill., in additions and improvements of properties were shown in the 1928 annual reports submitted at the stockholders' meeting, a 5 per cent increase in operating expense handling growing activities which netted 11.9 per cent gross income increase. Officers of the company were reëlected as follows: B. C. Cobb, New York, president; R. S. Wallace, vice-president and general manager; W. H. Barthold, New York, vice-president; H. G. Kessler, New York, comptroller; T. A. Schlink, Peoria, secretary-treasurer. Gross earnings from the electric, gas and heating departments were $4,765,844.80 against $4,391,161.25 in 1927; operating expenses, $2,817,129.87 against $2,650,287.24 in 1927 and net income, after amortization and interest on debt discount and expense, $1,587,858.32 against $1,325,009.93 in 1927. Preferred stock dividends were $408,837.13 and dividends on common, $700,000. During the year $661,495 was spent on improvements. Customer ownership has grown from 250 in 1918 to 4500 last year. The electric department showed 72 per cent of the gross earnings; the gas 22 per cent and heating, 6 per cent.

Exacting Demands of Industrial Heat Balance*

PROCESS REQUIREMENTS NECESSITATING CONSTANT PRESSURE AND TEMPERATURE CONDITIONS OFTEN REQUIRE A LAYOUT WHICH TAXES THE INGENUITY OF THE DESIGNING ENGINEER

INDUSTRIAL HEAT BALANCE layout, even with a simple system, is usually a complicated matter because of the fact that a number of independent variables must be taken into consideration. Boiler operation, electric power demand and process steam requirements all have an important bearing on the operation as a whole, and the layout must be flexible enough to take care of the steam variations in any one of these quantities without appreciably affecting the others.

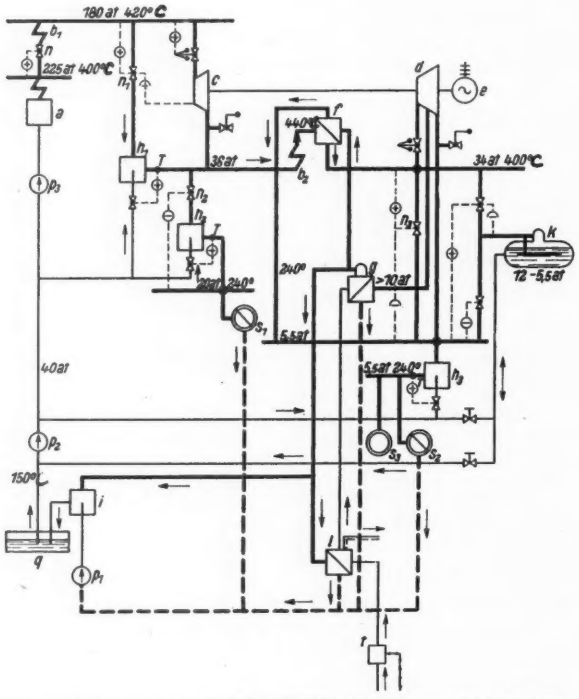


FIG. 1. HEAT BALANCE OF A GERMAN INDUSTRIAL PLANT, THE SIEMENS-SCHUCKERTWERKE, WHERE STEAM IS GENERATED AT THE CRITICAL PRESSURE IN A BENSON BOILER

At one of the power plants of the Siemens-Schuckertwerke, the problem is further complicated by the fact that steam is generated in Benson boilers[1] at the critical pressure of 224.2 atmospheres while the process steam demands as to temperature and pressure are exacting and must be maintained within close limit.

A complete schematic diagram of the equipment at this plant is shown in Fig. 1. Feedwater is fed to the boilers at 230 atmospheres, either by a double acting, six plunger power pump, driven by a variable speed direct-current motor or by a 16 stage centrifugal pump driven by a constant speed alternating current motor. Steam is generated in the boiler (a) at the critical pressure of 225 atmospheres, 400 deg. C. and passes through the reducing valve (n) to the superheater (b_1) and is delivered to the high-pressure stage of the turbine (c) at 100 atmospheres, 420 deg. C. Under full load operation, reducing valve (n) is wide open and the pressure drop from 225 to 180 atmospheres takes place through the superheater coils. At partial load, however, the drop through the superheater decreases and the reducing valve (n) is operating to maintain constant pressure on the turbine. In future installations, it is intended to connect this reducing valve with the turbine control.

Steam for process work is required at 20 atmospheres and 240 deg. C. and 5.5 atmospheres and 240 deg. C., conditions which must be maintained regardless of the operation of the turbine, so that considerable additional equipment not ordinarily required in a power plant is needed. Under normal conditions, the steam is expanded in the high-pressure turbine (c), (shown in cross section in Fig. 2) in two stages to 36 atmospheres. The pressure drop in the first stage is from 180 to 60 atmospheres, and the turbine is so designed that the high-pressure stuffing-box operates only under a pressure of 60 atmospheres and temperature of 350 deg. C.

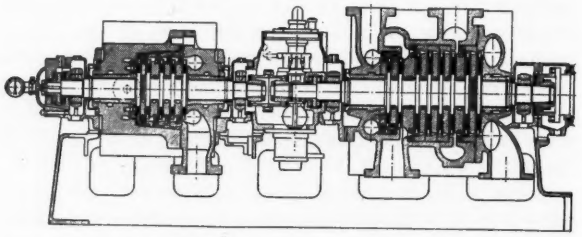


FIG. 2. CROSS SECTION OF THE 180 ATMOSPHERE TANDEM COMPOUND TURBINE

DESUPERHEATER USED IF TURBINE IS BYPASSED

If the turbine should be shut down, the high-pressure steam can be bypassed through the reducing valve (n_1) directly to the 36 atmosphere header, the temperature being reduced to that of saturated steam in the desuperheater (h_1), which is supplied by water from pump (p_2).

If the turbine is operating, a portion of the steam coming from the high-pressure turbine is throttled by the throttle valve (n_2) to 20 atmospheres, cooled in the desuperheater (h_2) from which it is used in process work, represented in this case by the circle (s_1).

The remaining portion of the steam from the high-pressure turbine is reheated to 240 deg. C. in the stage reheater (b_2), which, like b_1, is located in the second pass of the boiler. This superheated steam is used in the steam reheater (f) to heat saturated steam at 5.5 atmospheres 240 deg. C. This cools the high-pressure steam to about 400 deg. C., at which temperature it enters the low-pressure cylinder of the turbine (d) where it is expanded to 5.5 atmospheres.

About one-third of the steam flow to the turbine is

*From an article by H. Gleichmann in Siemens-Zeitschrift.
[1]See Power Plant Engineering, page 718, July 1, 1928.

bled at about 10 atmospheres pressure to the evaporator (g). Vapor at 5.5 atmospheres from the evaporator flows to the steam reheater (f), as described above, is heated to 240 deg. C. and delivered to the 5.5 atmosphere header. The balance of the steam through the low-pressure turbine expands to 5.5 atmospheres and is again mixed in the low-pressure header with the one-third coming from the reheater.

At an adjoining rubber works, a heavy momentary steam demand is encountered, so a Ruths accumulator (k) is connected to take steam from the 34-atmosphere header for charging and delivering it under decreasing pressure to the 5.5-atmosphere system.

With this arrangement alone, the steam temperature of the 5.5-atmosphere steam might drop below 240 deg. C., so the outlet temperature of the turbine is chosen somewhat above this temperature and held constant by the desuperheater (h_3). By an addition of steam from the accumulator, the water injection to the desuperheater (h_3) is varied. This gives a constant temperature of 240 deg. C. for the process work represented by (s_2) and (s_3), representing special requirements for rubber production. With the turbine shut down, the 5.5-atmosphere system can be supplied direct through the reducing valve (n_3).

Condensate from the processes (s_1) and (s_2), the evaporator (g), and the deaerating heater (1), drains back to the hotwell (q), through the feedwater heater (i).

Steam used in the process (s_3) is contaminated with acid and cannot be reclaimed. Makeup for this and other losses is supplied from the evaporator (g), mentioned above. Raw water fed to the evaporator is treated in a softening plant (t), and deaerated in the deaerator (1). Condensate pumped through the preheater and feedwater heater (i) is delivered to the elevated feed tank (q) at 150 deg. C., by pump (p_2) which supplies at 40 atmospheres the high-pressure pump (p_3), the desuperheaters (h_1) (h_2) (h_3) and the accumulator (k).

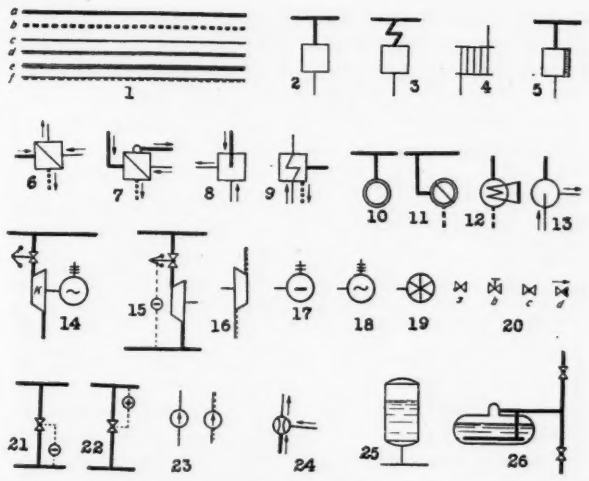


FIG. 3. SOME COMMON SYMBOLS USED BY GERMAN ENGINEERS FOR POWER PLANT DIAGRAMS

Although this concludes the description of the Siemens-Schuckertwerke plant, it is interesting to note the use of symbols as in the flow diagram, Fig. 1. With characteristic thoroughness, the Germans have given much thought and study to the development of a set of uniform symbols to be used in steam engineering.

They feel that the conventional diagram with the various parts drawn in cross section requires too much time and in many cases makes the drawing too intricate. They aim to obtain a simple presentation of a power plant layout by a symbolic method such as has been used for years in electrical engineering.

As a convenience in providing suitable symbols, the plant is divided into several parts as feed lines, heat exchangers, prime movers, generators, valves and pumps and control devices. Pipe lines are indicated as shown in Symbol 1, Fig. 3. In general, all heat exchangers including boilers are represented by a square while heat absorbing equipment such as process apparatus and condensers is represented by circles.

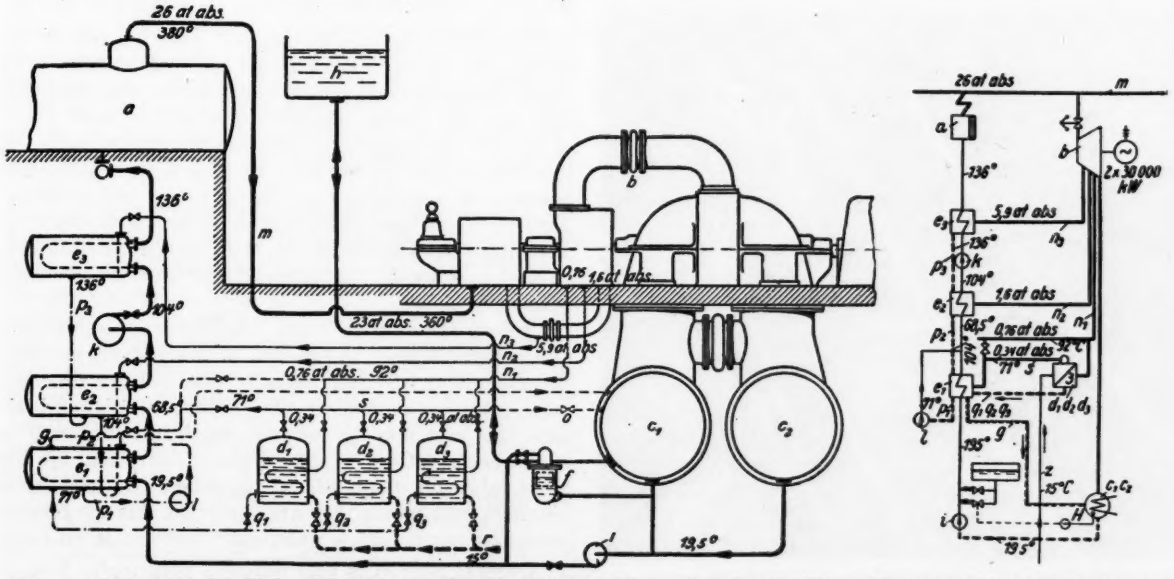


FIG. 4. DIAGRAM OF THE OERSTED PLANT IN COPENHAGEN. THAT ON THE LEFT IS THE CONVENTIONAL DIAGRAM, THAT ON THE RIGHT IS THE SAME DIAGRAM USING SYMBOLS

Prime movers are shown as the frustum of a cone and generators as a circle. Compressors are the same as prime movers but reversed in position to show compression instead of expansion. Valves are represented as double triangles and pumps as circles about half the size of those used for heat using apparatus.

A number of typical symbols are shown in Fig. 3. In symbol 1, a, b, c, d, e, f represent steam, condensate, water, flue gas, combustible gas and air lines respectively; 2 is a boiler; 3, a boiler and superheater; 4, an economizer; 5, a boiler and preheater; 6, a heat exchanger; 7, an evaporator; 8, an open heater and 9, a closed heater. Open and closed process tanks are represented by 10 and 11; surface condensers as 12 and jet or barometric condenser as 13.

Prime movers are shown as in 14; turbines and engines are differentiated by using the initial letter of the word. Symbol 15 represents a turbine with automatic control of back pressure. Compressors are shown reversed as in 16 while generators are represented by circles, 17 being a direct current generator and 18 a three-phase alternator. Gears and mechanical transmissions are shown as in 19.

Valves are double triangles, different types being shown in symbol 20 where a, b, c and d represent general valve symbols, hand operation, automatic operation and nonreturn valves respectively. Pressure controlled valves are sometimes shown as 21 and 22 the dotted line and symbol plus or minus indicating whether the valve is controlled by the higher or lower pressure. Pumps and blowers are shown as 23 and ejectors as 24.

For purposes of illustration, Fig. 4, flow diagrams of the Oersted plant at Copenhagen are shown, at the left, the conventional diagram and at the right the same diagram using symbols. Those familiar with the conventional diagram may question whether or not the symbols simplify or complicate the diagram. The same system has, however, been a decided success in electrical engineering and should be of decided advantage after it is used widely and extensively enough to become familiar to all engineers. The saving in drafting time alone is an item of considerable importance.

Anti-Friction Bearings for Central Station Use

By L. M. Klinedinst*

IN EQUIPMENT for station service, development has kept pace pretty well with changes and innovations in station design and operation, so that, taken as a whole, it is capable of meeting all the service demands likely to be made upon it. Nevertheless, the growth in the size of individual stations, that has followed the policy of concentrating the generation and distribution of power for wide areas at a few points, has given importance to the economic side of the station service problem. It is probably reasonable to say that, in the large steam station of today, the majority of the installed equipment comes under the head of station service. Even in the case of hydroelectric stations, there is enough service equipment to affect materially the cost of producing power.

Since most service equipment proper is of a mechanical nature, the operating problem provides room for the exercise of ingenuity in the selection and application of equipment with a view to keeping down operating costs. It might also be said that proper selection of mechanical equipment can and does exert considerable influence on the selection of the electrical equipment. It affords opportunities for considerable saving in the initial investment and operating costs, of the generating, transforming, and distribution equipment.

*Manager, Industrial Dept., Timken Roller Bearing Co.

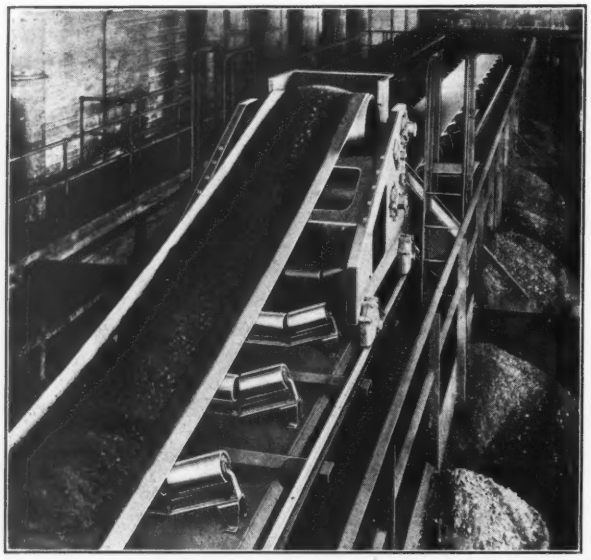


FIG. 1. ANTI-FRICTION BEARINGS USED ON BELT CONVEYOR TO STORAGE BINS

Type of Bearings Is Important

One potent factor affecting the operating cost of the station service equipment is the type of bearings with which the individual pieces of apparatus are equipped. Most station service equipment, whether taken singly or in mass, is characterized by heavy friction loads. If the friction can be reduced, as it is with anti-friction bearings, a considerable saving in power will be made. Actual percentages saved depend on the particular type of equipment in question but, with any installation considered as a whole, the aggregate savings are of consequence.

Among the various items, entering into maintenance and general operating expense, is lubrication, not only the amount of lubricant actually used but the time and labor expended in applying it. With anti-friction bearings, this cost may be reduced, sometimes, as much as 90 per cent. Of course some types of equipment require more lubricant than others, regardless of the sort of bearings with which they are equipped, but the relative reduction percentage is practically uniform in all cases.

General upkeep is also reduced, principally because anti-friction bearings improve the performance of the

equipment on which they are used, as to both life and effectiveness. As a result, the expense for material and labor on repairs and replacement of parts, not necessarily the bearings, and the expense and trouble caused by machine outages all are reduced.

In the design and construction of different machines either intended or adapted for station service, use of anti-friction bearings has been growing, so that it is possible to take advantage of the improvements they effect in practically every type of apparatus used for station service. It may be interesting to consider the results from application of anti-friction bearings to various types of equipment.

Friction and Lubrication Reduced

Practically every steam station employs conveyors, either belt or pan, for some purpose, either transfer of coal, or ash disposal. Regardless of type, conveyors form a heavy, sustained friction load on the driving mechanism, which is complicated by specially high starting inertia. The result of this is that conveyor motors are generally selected on their ability to start the conveyor, which means that they are too large for normal running demands. If induction motors are used, as is usually the case, the overall power factor of the drive is likely to be poor, a condition the undesirability of which needs no elaboration.

When conveyors are equipped throughout, including belt idlers, return idlers and head and tail pulleys, with anti-friction bearings, the starting inertia is reduced so that a motor chosen for normal running has overload capacity more than sufficient to handle the starting. Overpowering is no longer necessary, the power factor, in the case of induction motors, is improved and it is even possible, by employing motors of lower continuous horsepower rating, to save on the initial investment and fixed charges for the drive.

Anti-Friction Bearings on Conveyors

In lubrication and general upkeep expense, anti-friction bearings have a great influence on conveyor operation. Every conveyor incorporates a large number of bearing surfaces whose lubrication must be constantly attended to. Where large conveyors are employed, often the entire time of two or three men will be taken in attending to their lubrication, the amount of lubricant used and wasted being proportionately large and costly.

With anti-friction bearings, since the housings can easily be designed to retain the lubricant and the whole interior of the roller, the wheel or the pillow blocks on the pulley shafts may be utilized as a reservoir for lubricant, the necessity for frequent renewal is eliminated with, naturally, reduction in the amount of lubricant used and the time and labor to apply it. What this means to the overall operating cost of the station depends entirely on the number and length of the conveyors used but, in any case, it will be of material benefit.

As to general upkeep, anti-friction bearings will wear better than plain ones because of superior construction, materials and lubrication. Also the life of rollers and belts, in belt conveyors, is lengthened, as there is no tendency for rollers to jam and produce flat spots, which are detrimental to both the roller and the belt.

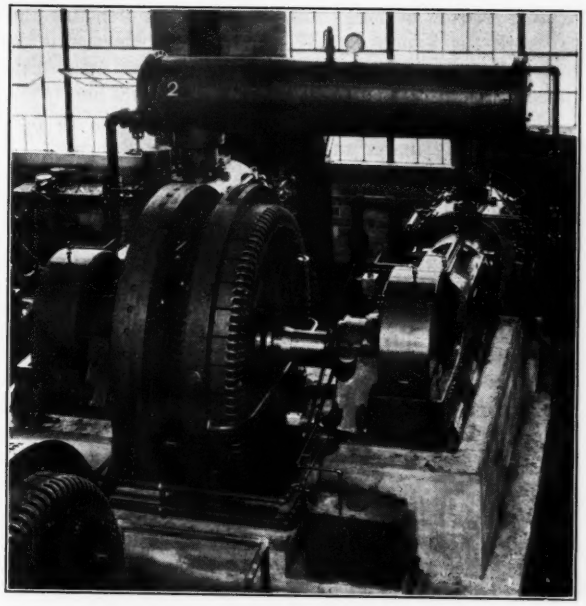


FIG. 2. AIR COMPRESSOR HAS ANTI-FRICTION BEARINGS AND SYNCHRONOUS MOTOR DRIVE

Growing use of pulverized coal has given impetus to pulverizer design, one result being that anti-friction bearings have been applied to pulverizers of both the hammer mill and gyratory types. In the hammer mill type, the bearings are mounted on the hammer mill shaft where shaft rigidity rather than reduction in friction is of the greatest importance. Experience has proved that anti-friction bearings will preserve shaft rigidity longer than plain bearings, thereby adding considerably to the life of the machine, besides reducing the expense of maintaining proper lubrication.

In gyratory crushers, anti-friction bearings are being applied in step and guide positions on the main vertical crusher shaft, as well as to gear and pinion shafts of the driving mechanism. In the former positions, these bearings have solved the problem of carrying a heavy crushing load complicated by shock of varying severity and, at the same time, reducing the power demand of the machine. A comparatively simple lubrication system proves adequate. In the case of a plain-bearing failure or even trouble, the expense of dismantling the machine once to get at the bearing is usually more than enough to pay for the complete installation of anti-friction bearings, which seldom require replacement or repair. For this reason alone, the employment of anti-friction bearings is worth considering.

Pumps, Compressors and Blowers

In application of anti-friction bearings to pumps, the principal benefits are the assurance of continuity of service and reduction in lubricant and maintenance costs. For centrifugal pumps, shaft alinement is preserved, which is important, since the performance of the pump is directly dependent on the maintenance of the proper clearances between the different members. In both centrifugal and reciprocating pumps, the use

of anti-friction bearings reduces the power demand and saves in the expense and trouble of lubrication. As pumps are frequently located in places that are quite inaccessible, so that their lubrication is liable to be neglected, the ability of anti-friction bearings to perform properly under such conditions is a real asset.

Compressors and blowers have, for all practical purposes, the same characteristics as pumps and much the same benefits follow the use of anti-friction bearings. The effect on overall operating costs may be less because more pumps are used than compressors or blowers in the average station, still it does have an effect that is worth considering.

Electric Motors

In practically every central station, the entire station service may be considered as a motor load. The past few years have seen a considerable advance in the application of anti-friction bearings to motors of all types and especially to general purpose induction motors, which compose the majority of those used for station service.

Anti-friction bearings have a decided influence in securing continuity of motor operation, as it is pretty well conceded that, ordinarily, the bearings are the most vulnerable point in motor construction. Their failure is probably responsible for most of the outages and interruptions to service. Anti-friction bearings go a long way towards eliminating such outages.

In a station operating a large number of motors, the expense for lubricant, the time and labor necessary to apply it and to inspect to see whether or not it is feeding properly, all add considerably to the running costs. Experience has shown that electric motors will run from six to nine months on one grease supply, when anti-friction bearings are used.

Thus have been indicated broadly the benefits that may follow the use of anti-friction bearings on different types of apparatus. It can probably be argued that saving a few dollars a year in the operation of a small number of pumps, or motors, or compressors is hardly a reason for changing over the equipment to another, and perhaps more expensive bearing, which is probably true. But, when the whole mass of equipment is taken into consideration, a few dollars saved here and there become a lot of dollars saved altogether—enough, in even a comparatively small station, to be well worth while considering.

Recent Developments in Unit Heater Design

Considerations Influencing Heater Sections, Fans and Air Circulating Arrangements; Analysis of Fan Performance. By S. M. Anderson*

IT HAS LONG been recognized that the heating of buildings and industrial plants is not entirely satisfactory when attempted by the use of pipe coils or of special cast-iron sections of heating elements placed along the walls or in advantageous portions of the buildings. With such installations, stratification of the air, a condition now commonly recognized by all heating and ventilating engineers, often causes temperatures much warmer near the ceiling than necessary for comfort and at the same time an equally unsatisfactory stratum of cool air near the floor. Such stratification results in uneconomical heating. Heating engineers then undertook to produce a forced circulation of air to combat these undesirable conditions. Large central fan systems, necessitating extensive duct-work layouts, were designed and operated successfully over a long period of years. These systems, however, lacked one important attribute—that of flexibility of installation. Once laid out and balanced, it was almost impossible to rearrange the heat distribution to meet growing needs.

In appreciation of these facts, the unit system of heating was evolved, utilizing the same steam coils in conjunction with a fan or fans, made up in compact form and resting upon the floor. Most of the earlier units drew the air from the floor, passed it through pipe coil heaters and discharged it near the ceiling. Later developments replaced the pipe coil heater and its associates with much lighter and more compact "extended surface" or "fin" tubing, giving approximately 15 times the heating surface per foot of length that could be obtained from a straight pipe having the same internal diameter. In general, therefore, the compactness of the heating unit became proportioned on dimensions approximating this fifteen to one ratio. For a given thermal capacity, the design of the heating element passed through an evolution from many rows of parallel pipe coils having a high resistance to the flow of air passing through them to a unit made up of one, two or three rows of extended surface offering a much lower resistance to the flow of air.

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Three Essentials of Design

This almost phenomenal growth of the modern unit heater has resulted in a variety in form and design so great as to perplex the most profound investigator of the requirements of a good heater. The elements to be considered, however, are really few and in analyzing the design of the unit heater there are but three essentials: first, the heating section itself; second, the fan or impeller; third, the general arrangements whereby an effective circulation of air can be obtained. Under the last heading might be considered also the always important factor of floor space occupied by the unit.

Requirements of a heating surface are two-fold; namely, that it must have a high coefficient of heat transfer and that at the same time it must not offer an excessive resistance to the flow of air passing through it. Extended surfaces having such low resistance qualities with high thermal capacities often employ a perfect, continuous metal fin, often amalgamated to the pipe core with solder or other amalgamating metal which will have a melting point at about 400 deg. above the maximum temperature to which the steam within the heating element is to be raised. Copper tubing bent to the desired shape or fastened in short straight sections to a common header seems to answer this purpose most satisfactorily. Such tubing not only amalgamates

quickly with high melting-point solder, but also has non-corrosive qualities. At the same time, copper tubing can now be manufactured to withstand steam pressures as high as 350 lb. per sq. in. Hydraulic tests on copper tubing have shown commercial results as high as 700 lb., and in development tests as high as 1000 and 2000 lb. per sq. in. gage pressure.

Propeller Fan Advantages

Use of the low resistance extended surface tubing offers a further contribution toward compactness and lightness of construction in the type of fan best suited to circulate air through the unit. Tests indicate that a propeller fan, when properly designed and operating at a resistance point at or near its wide open volume, has an efficiency higher than any other type of fan under the same conditions; furthermore, it reaches its peak of efficiency at a resistance point not far back from the wide open volume. Another feature of the propeller fan which, it is claimed, makes it particularly adaptable to unit heater performance, is the fact that the horsepower required to operate the fan when blowing air under no resistance whatever is actually less than when blocked off entirely. The power remains substantially constant whatever the operation of the fan, and is at the lowest figure, for volumes of air delivered, between 65 per cent and wide open volume.

Herewith is a performance curve, Fig. 1, of a warped-blade propeller fan in which the horsepower, pressure and static efficiency are plotted as ordinates, against the per cent of wide open volume of air delivered as abscissas. This chart clearly indicates the above points in respect to the slowly drooping horsepower curve between 55 and 100 per cent wide open volume and the maximum static efficiency at an orifice of 75 to 80 per cent wide open discharge volume. For these reasons a propeller fan is considered by many engineers to be the type best suited for use in a low resistance unit heater, not only on account of its lightness and high efficiency, but also because it has a virtually self-limiting horsepower characteristic.

A unit heater equipped with a propeller fan and having short runs of duct-work, with dampers, leading from the unit to various rooms or portions of the same room to be heated, should not give serious motor overload trouble caused by adjustments of the dampers to obtain different distributions of heat, unless, of course, the entire unit is blocked off to 30 or 40 per cent of its wide open volume. Such a condition would rarely occur in actual practice, as a complaint of too much heat usually results in shutting down the unit rather than in keeping it in operation and closing dampers. Furthermore, a unit heater built with a propeller fan and having a dry air filter or other resistance to overcome, is not affected by motor overload trouble in case such resistance is removed either temporarily or permanently.

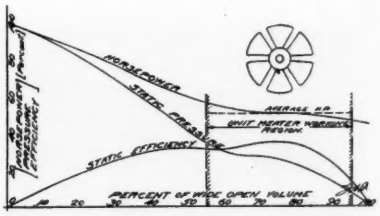


FIG. 1. CHARACTERISTIC CURVES OF CONSTANT-SPEED SIX-BLADE PROPELLER FAN

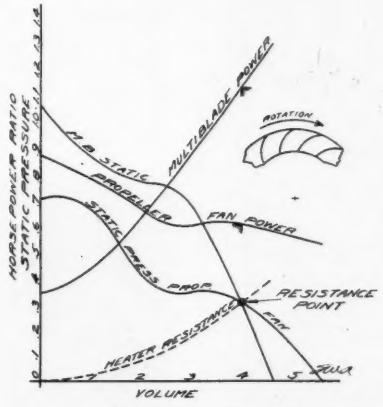


FIG. 2. HORSEPOWER AND PRESSURE CHARACTERISTICS OF MULTI-BLADE FAN AND SIX-BLADE PROPELLER FAN. (BOTH FANS OF MAXIMUM SIZE TO FIT IN HEATER 25 IN. WIDE.)

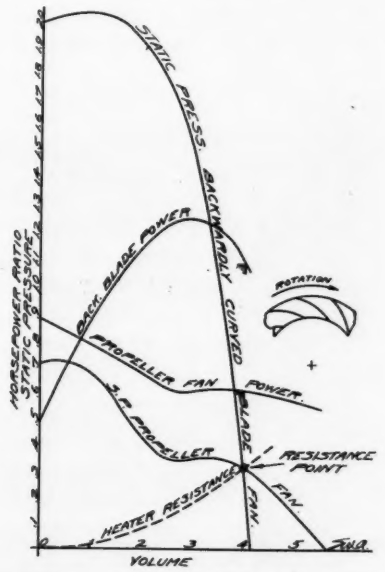


FIG. 3. HORSEPOWER AND PRESSURE CHARACTERISTICS OF BACKWARD-CURVED BLADE FAN AND SIX-BLADE PROPELLER FAN. (BOTH FANS OF MAXIMUM SIZE TO FIT HEATER 25 IN. WIDE.)

Comparison of Various Fans

Examination of the performance curves shown below, one for a forwardly-curved or multi-blade type fan, Fig. 2, and the other for a backwardly-curved type fan, Fig. 3, will disclose the fact that neither possesses those qualities of the propeller fan just discussed. A multi-blade type fan is constructed for high-pressure duties. In Fig. 2, the resistance of the heater is represented at about 4000 c.f.m. against 0.3 in. static pressure; the speeds of the two fans are adjusted to give, at some point along their characteristic curves, a pressure and volume equal to the resistance of the heater.

Horsepower relationship is an inverse function of the efficiency of each fan, respectively, at the heater resistance point. For example, if for any reason the volume should change from 4000 to 4700 c.f.m., the propeller fan power would actually drop off, whereas the multi-blade power would rise on a steep curve high enough to overload a closely designed motor. On the contrary, although the power would remain practically

constant for the propeller fan if blocked off to almost 2000 c.f.m. (about 50 per cent of the designed volume) the multi-blade power would drop so rapidly that at this point it would be exactly equivalent to the propeller fan power.

In Fig. 3, the performance of a backwardly-curved type fan of the largest size permissible to fit in the same space as the same propeller fan is compared in a like manner. Such backwardly-curved fans are built for high efficiency duties, with self-limiting horsepower characteristics. As before, the propeller fan power is much lower than the power of the backwardly-curved blade fan at the resistance point of the heater, indicating that the propeller fan at this point is of much greater efficiency. Conversely, however, a reduction in volume due to the closing of dampers would actually increase the power required by the backwardly-curved blade fan sufficiently to overload the motor driving it. Not until one-fourth of the operating volume of the heater has been reached does the backwardly-curved blade fan power equal that of the propeller fan. The relationships just described are not, of course, absolute for all types of multi-blade or backwardly-curved blade fans, or for all types of propeller fans, as much depends upon the skill of design in every case. They are, however, representative of typical fans of present day manufacture and include what is usually considered the most efficient backwardly-curved blade fan that has ever been designed.

It would seem, therefore, that for light-weight unit heater performance, centrifugal fans, which are constructed for a maximum efficiency of operation at points of 40 to 50 per cent wide open volume and high static pressure, should give way for economy of operation to warped-blade propeller fans. This fact has often been disputed and is still a questionable point among many users and producers of heating units. It is argued that propeller fans cannot be efficient because of a "dead space" or region of practically no useful air-flow at or near the hub of the wheel. Various methods have been followed in the attempt to overcome the disadvantages of such a design. Usually a propeller fan in which this difficulty arises will discharge the air at a relatively low velocity from the fan wheel in a spiral cone having rapidly divergent elements. Some of the devices that have been used to correct this fault, with more or less satisfactory results, have taken the form of enlarged hubs and blades hooked at the end to prevent the action of centrifugal force on the particles of air.

In the case of propeller fans on unit heaters such changes do not aid materially in the performance of the fan, and, in some cases, they actually reduce its volumetric delivery at a given speed and resistance. A properly designed propeller fan, however, that is, one with warped-blade surfaces, should reduce the "dead space" to a minimum and should deliver a large volume of air at a relatively high velocity in the axial direction of the air-flow without the use of any device to correct the centrifugal effect.

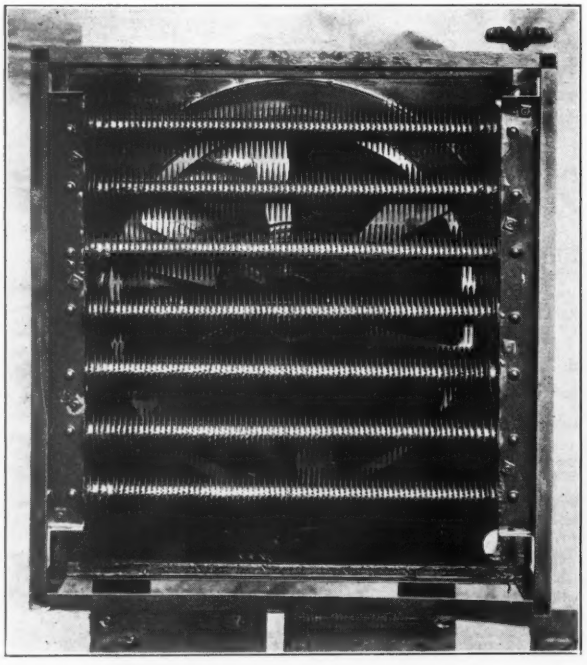


FIG. 4. UNIT HEATER WITH ONE ROW OF EXTENDED SURFACE HEATING ELEMENTS AND PROPELLER FAN

FIG. 5. UNIT HEATER, WITH EXTENDED SURFACE AND PROPELLER FAN, HAVING LOW DISCHARGE VELOCITY. RECIRCULATING BOX PROVIDES EFFECTIVE AIR CHANGE

FIG. 6. UNIT HEATERS IN AIRPLANE FACTORY DISCHARGING AIR TO FLOOR AT HIGH VELOCITY THROUGH DIFFUSING CHAMBERS

Air Circulating Arrangements

Third element of unit heater design, the general arrangement whereby an effective circulation can be obtained, has been treated in two ways. One method consists in the use of recirculating boxes to overcome the disadvantages of propeller fans of low velocity discharge. Cool air is forced to enter such a heater at the floor and is carried up to the fan through the heating element by a large metallic duct or riser, known as a recirculating box, to be discharged at or near the ceiling as heated air.

Various objections have been raised to these units, such as complaints of chilling drafts near the floor line, local recirculation with cold spots in parts of large rooms, and so on. Most of these complaints are more psychological than real as, in the majority of cases, the low velocity unit heater with well-constructed recirculating boxes gives extremely good results.

In the past year, however, a further development

has been made, employing a more efficient and carefully designed propeller fan, which does away entirely with the recirculating boxes and obviously results in a saving of both floor space and cost of installation. Such units utilize to every advantage the characteristics of the warped-blade propeller fan as previously outlined. This fan, mounted directly upon the motor shaft in a thimble of proper proportions, discharges into a large diffusing chamber, through the heating element into a second diffusing chamber and forces the air through outlets directing it as desired. By the use of adequate diffusing chambers, an advantage is obtained in the conversion of the velocity pressure of the air as it enters the chamber into static pressure, to be reconverted into velocity pressure as it leaves the outlets.

In this manner and by careful design of outlet bends in accordance with the natural streamline flow of fluids around a bend, a relatively high-discharge-velocity, propeller-fan unit heater has been produced. The velocity of air leaving the outlets of this later type of unit ranges between 1000 and 1800 ft. per min., depending upon requirements. Tests conducted on this heater indicate that equally good if not better recirculating qualities are obtainable with it than with the older recirculating box unit. Velocity of the air leaving the unit sets in motion the entire air content of the room to be heated, with the result that the heat discharge from the unit is carried from the ceiling straight to the floor. It diffuses in its path with the other air of the room to form a comfortable mass of warm air moving slowly at a distance of two or three feet from the floor and displacing an equal volume of cool air by forcing it to rise to the upper levels and into the inlet of the heating unit by the suction created behind the propeller fan. Further observations of a unit of this type indicate that it may be placed as high as 18 to 20 ft. from the floor level with good results and that the heat discharged from the outlet of one unit will reach the floor, forcibly displacing air at the floor at a distance of 50 ft. from the outlets.

In general, therefore, it appears that best results can be obtained by the use of a heating system composed of a number of small units suspended near the ceiling, diffusing the air which they heat throughout the room at a velocity sufficiently high to give adequate recirculation without the use of recirculating boxes or risers extending to the floor. Such a heating system combines the major features of adequate recirculation, maximum economy of operation, ease and flexibility of installation and reasonable initial cost—all factors that attract most forcibly the attention of the architect, engineer and business executive of today.

Mittlere Isar A-G Hydroelectric System

DEVELOPMENT IN SOUTHERN GERMANY HAS CAPACITY OF 112,000 KW. IN FOUR PLANTS. MODEL TESTS WERE MADE OF TURBINES. BY BLAKE R. VAN LEER*

AT THE CLOSE of the World War, the treaty of Versailles deprived Germany and Austria of many of their coal fields. This gave an unusual impetus to the development of hydroelectric power; one of the largest developments in Southern Germany is known as the Mittlere Isar A-G. The general plan of this project is shown in Fig. 1.

A short distance outside the city of Munich an intake weir diverts a portion of the water of the Isar River into an artificial canal which conducts the water for 2 to 2.5 mi. or approximately parallel to the river, then in an easterly direction, where it passes an artificial reservoir known as the Speicher See. This reservoir is 0.6 mi. wide, 4.5 long, has a capacity of 107,000,000 cu. ft. It is used to store flood waters for use during the dry season. Immediately following the Speicher See is the first power plant, known as Finsing, Fig. 2B. Down the canal 7.3 mi. the second plant, Aufkirchen, is located, Figs. 2A and 2D and 4 mi. still farther along the canal is the third plant, Eitting, Fig. 2C. Here, for the time being, the water is diverted again into the Isar River.

It will be noted that the Mittlere Isar A-G is exclusively a hydroelectric development and has no standby steam plants. It has a contract, however, with the state and with the net-work of power companies which, of course, have ample steam reserves. At present the total cost of steam generated power is much lower in Germany than would be the cost of any new hydroelectric developments, hence it is doubtful whether more plants

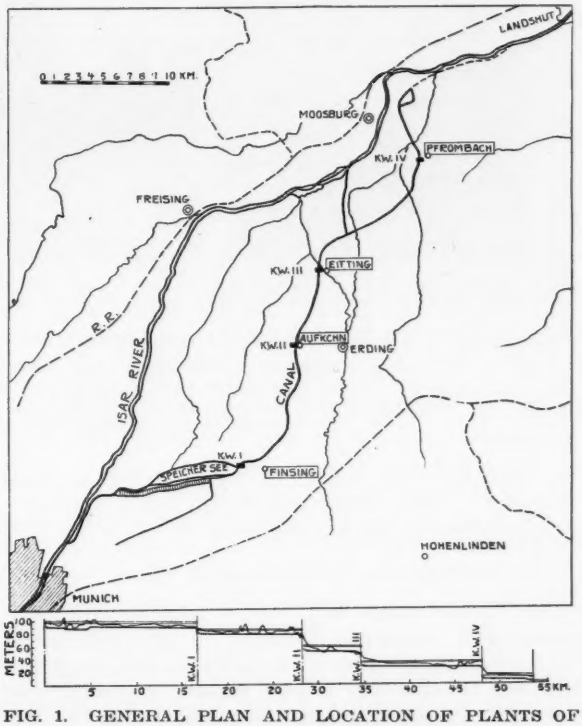


FIG. 1. GENERAL PLAN AND LOCATION OF PLANTS OF MITTLERE ISAR A-G

other than those now under construction will be built until the balance of economy is more favorable to hydroelectric power. The hydroelectric developments of Southern Germany and Austria are of special interest

*Assistant Secretary, American Engineering Council. This article incorporates some of the data collected in Europe by Mr. Van Leer in 1927 and 1928 when he was conducting research work there as John R. Freeman Scholar.

to Americans because most of the capital supplied for their construction came from America. The essential and interesting technical data concerning each plant of the Mittlere Isar A-G are given in the table.

Large portions of the energy generated are supplied the railway system of Bavaria, about 10 per cent of which is now electrified. Combined with the Walchen-

slightly higher efficiency, better operating characteristics from the turbine standpoint and a more modern unit. Because of the limited funds at the disposal of the purchaser, however, a type of turbine was adopted which would make the total cost of construction of the plant as low as possible. A contract was drawn which required the manufacturer to make model tests and

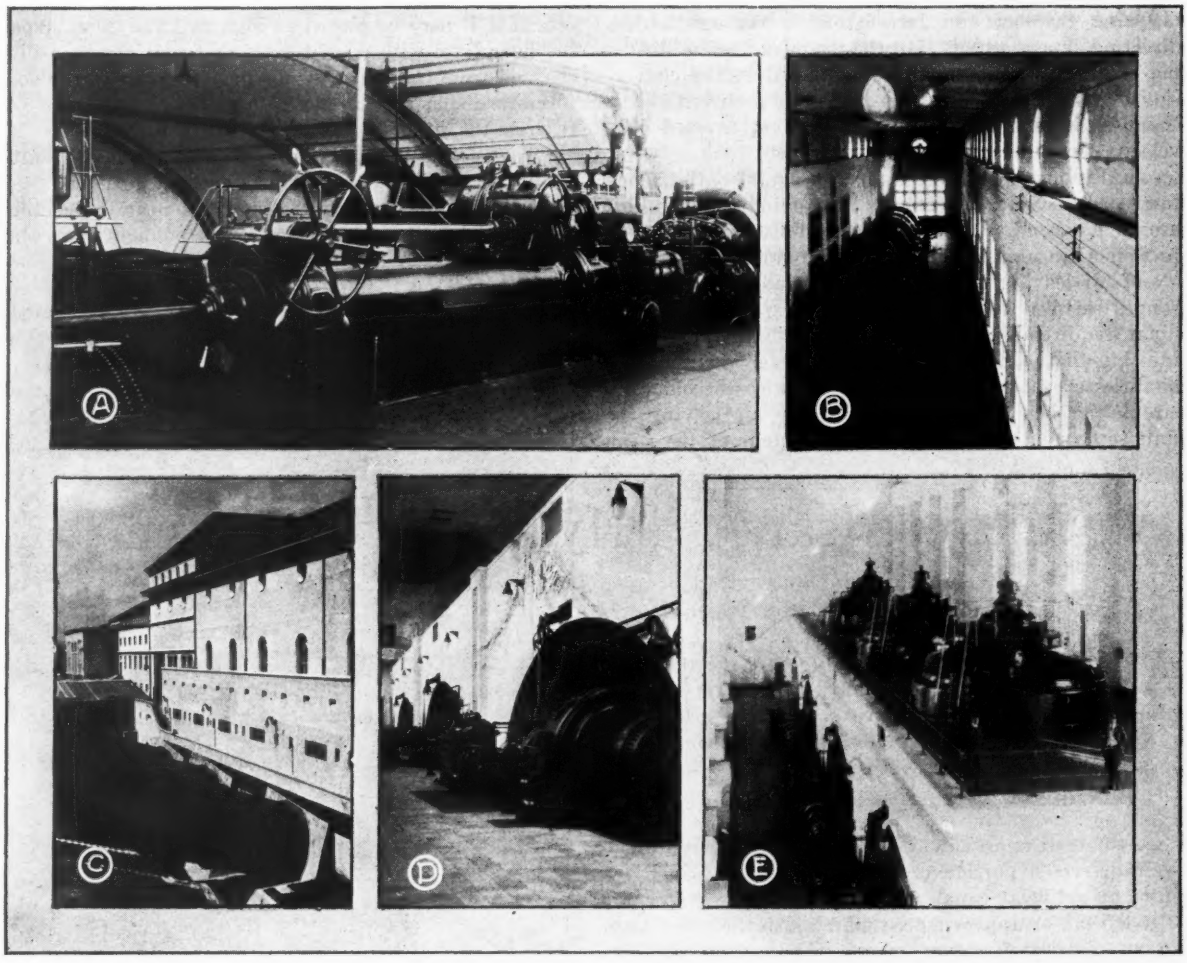


FIG. 2. VIEWS OF EQUIPMENT IN SEVERAL OF THE HYDROELECTRIC PLANTS OF THE MITTLERE ISAR A-G

A—Special governor in Aufkirchen plant, designed by Dr. Thoma, for automatic, hand or remote control. Governor actuates gates and air vent in draft tube. B—At Finsing plant, each generator is driven by four hydraulic turbines mounted on the same shaft. C—Exterior view of Eitting plant. D—General view of turbines at Aufkirchen. E—Turbines at Eitting plant

see Plant there is available through installed machines 112,000 kw., which makes possible the yearly generation of approximately 480,000,000 kw-hr.

Features of Pfrombach Plant

Pfrombach Plant will have a total of eight horizontal-shaft, spiral-case turbines. A unit will consist of four of these turbines, mounted on one shaft and driving one generator. This feature, combined with very difficult entrance conditions from the penstock to the turbines, presented a difficult problem to the turbine maker, J. M. Voith of Heidenheim, Germany, who would have much preferred to make only two vertical turbines of the propeller type. The latter would have given

which offered a bonus of 30,000 r.m. (about $7500) for each per cent of efficiency over 87 per cent.

This matter of requiring model tests is one that could well be followed in America to the advantage of all concerned, in the writer's opinion.

Model Tests Were Made of All Turbines

In Europe, model testing in all phases of hydraulics is more extensive than in America. In predicting the maximum efficiency of a full scale turbine from the maximum efficiency obtained from a model test, the formulas most generally used are:

1. The Moody formula,

$$E = 1 - (1 - e)\ (d/D)^{1/4}\ (h/H)^{1/10}$$

2. The Cammerer formula,

$$E = 1 - (1 - e)\ [(1.4 + \sqrt{1/D}) \div (1.4 + \sqrt{1/d})]$$

Where E is the maximum efficiency of the full scale turbine.
e is the maximum efficiency of the model.
D is the diameter of the full scale turbine.
d is the diameter of the model.
H is the head on the full scale turbine.
h is the head on the model turbine.

In the Aufkirchen plant, the Cammerer formula gave a predicted efficiency of 91.1 per cent and the Moody formula gave a predicted efficiency of 93.7 per cent. The actual acceptance test showed an efficiency

TABLE SHOWING PRINCIPAL CHARACTERISTICS OF TURBINES IN THE FOUR PLANTS OF THE MITTLERE ISAR A-G

Plant	H.P. a. unit b. range c. total	Head ft.	Quantity cu.ft./sec. a. unit b. range	Speed R.P.M.	Spec. Speed N_s metric	Eff. %	Length of intake, mi.	No. and kind hyd. turbine
Finsing Dec.1924	a. 1700 b. 1000 1700 c.13,600	20 38	715.0 370	125	360	84	10.6	8 Horz Francis Turbine
Aufkirchen Dec.1924	a.12,700 c.24,200	86.0	1500	167	322	92.6	7.4	4 vert spiral Francis turbine
Eitting 1925	a.12,700 c.32,800	83.5	1500	167	322	89*	3.95	5 vert spiral Francis turbine*
Pfrombach	a. 3,900 c.32,000	70.1	590	250	340	91	11.7	8 Horz Francis turbine

*There is to be a fourth turbine installed in this plant this year.

*There was an error in this test because of the clock used, which was subsequently found to be out about 1 per cent. These units are identical with those at Aufkirchen and should have produced the same efficiency.

of 92.6 per cent or between the two, indicating that the Moody formula gives results a little too high and the Cammerer formula a little too low. There has also been recently published another formula known after the man who proposed it as the Staufer formula. It is exactly the same as the Moody formula except that the exponent for the ratio of heads is ⅛ instead of 1/10. In the case of the Aufkirchen plant, this formula would give still higher results than the Moody formula. The data available at present do not seem to warrant making a differentiation between exponents of 1/10 and ⅛.

Importance of Proper Draft Tube Design

One frequently finds in America strong partisan advocates of a special type of draft tube. In Europe, engineers seem to have no particular favorites but have taken the position that irrespective of how efficient a draft tube may be in recovering velocity head, its final effect upon the overall efficiency of the turbine may not be as good as another type because of velocity directions, cavitation possibilities and other factors. These matters are as yet impossible of prediction mathematically, hence the only reliable way of determining which draft tube is most suitable for a given turbine runner is to conduct model tests of the runner with various possible draft tubes and thus to determine which tube is most suitable for the turbine to be used. This is but another way of saying that the draft tube is a part of the turbine and should be designed with it.

For the Pfrombach plant the runner, which has fourteen blades and is of the Francis type, 64.5 in. in diameter, has been tested in a model of 12.4 in. diameter (or on a scale of 1:5.2) with three different draft tubes; the maximum efficiency of the model was in excess of 85 per cent, which assures the manufacturer of an efficiency in the full scale of 90 per cent. By further small changes in the draft tube, it is hoped that this efficiency may be raised to over 91 per cent, which is good considering the severe conditions of entrance of the water to the turbines.

Housing for the Pfrombach turbine follows what is now common practice in Europe on low and medium head plants; it is of sheet steel, riveted and welded together. This type of construction is used extensively in Europe on account of its cheapness. Gates of the Pfrombach plant are to be automatically regulated by floats. The gates are 65 ft. long, 23 ft. high and are constructed by J. M. Voith, Heidenheim, Germany.

Boiler Feed Pump Governor

BOILER FEED pumps are always fitted with some type of governor or regulator which maintains a nearly constant pressure in the line regardless of the amount of water being used by the boiler. The action of these regulators depends largely upon the type of pump used.

With direct-acting steam-driven pumps, it is customary to control the speed of the pumps by a governor valve located in the steam line. This valve is operated by the water pressure in the feed line. A drop in pressure opens the valve, admitting more steam and speeding up the pump, while a drop in pressure has the opposite effect.

Power-driven feed pumps are generally used only in small sizes and are usually operated at constant speed. They are designed of such a capacity as to meet the maximum demand, any excess water at light boiler loads being bypassed back to the suction through a spring loaded relief valve.

Due to the operating pressure discharge characteristic of centrifugal pumps, they are, in the usual small installation, operated at constant speed. The pressure in the feed line is allowed to rise slightly at low loads, the pump being selected to give sufficient pressure at the maximum load. In large installations, considerable power can be saved by variable speed drive. Fundamentally these governors are similar to that used for steam pumps. For steam turbines, the steam supply is varied, while for motor drive the feed line pressure is made to actuate a variable speed motor controller.

Modern high-pressure, high-rating plants require additional regulation and an excess pressure regulator is installed before the feedwater regulator to maintain a constant pressure differential between the steam pressure in the boiler and the pressure in the feed line just ahead of the feedwater regulator.

POWER PLANTS intended for peak load service only should be installed for the lowest possible first cost and economy of equipment can be sacrificed in order to secure this low cost. Base load plants, on the other hand, justify utmost refinements for heat reclaiming and high first costs.

Pipe Fitting by Use of Template

IT SOMETIMES HAPPENS that a connection must be made between two pipes lying in different planes and at an angle to each other. To bend pipe so as to get a

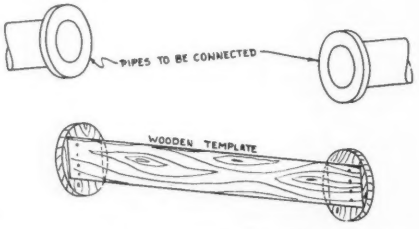


FIG. 1. SOLID WOODEN TEMPLATE FOR CONNECTING PIECE BETWEEN PIPES LYING IN DIFFERENT PLANES

good fit, a template may be made as shown, using two circular disks of board and tacking a filler of 2 by 3-in. post securely between them.

With such a template, a pipe fitter can make up the bend in the shop in any manner he pleases as long as the flanges check up with the template. It is almost impossible to make a bend fit right from measurements. Bends so made usually must be sprung into place.

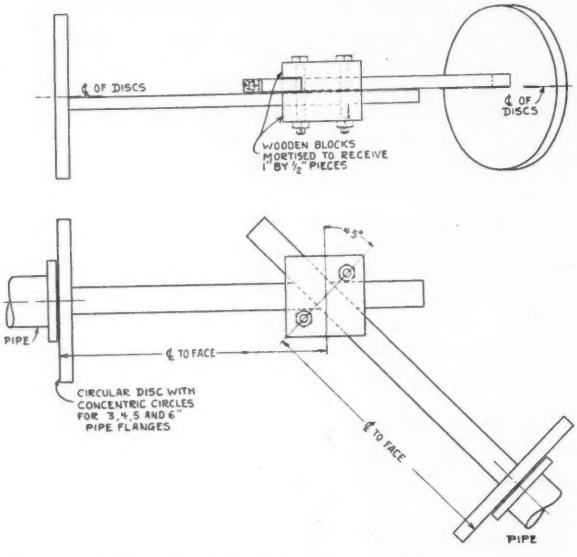

℄ OF DISCS
WOODEN BLOCKS MORTISED TO RECEIVE 1" BY ½" PIECES
℄ OF DISCS
45°
PIPE
℄ TO FACE
CIRCULAR DISC WITH CONCENTRIC CIRCLES FOR 3, 4, 5 AND 6" PIPE FLANGES
℄ TO FACE
PIPE

FIG. 2. ADJUSTABLE TEMPLATE FOR 45-DEG. PIPE TURNS

Templates for this purpose may be made adjustable as shown in Fig. 2, in which the center to center distances may be changed at will for a 45-deg. bend. In this case, the connecting piece may best be made of two blocks of wood bolted together, each block having a square recess cut into it from the face which is adjacent to its companion block, for the reception of a square rod, to the end of which is attached a blank flange as shown.

The rods are made square to avoid turning in their recesses and the flanges are placed off center on their respective rods in order to have the true center line run between the two connecting rods and through the plane of the faces of the two blocks.

Lincoln, N. H. A. P. NUTTER.

Cushion Port Action in Pumps

ON PAGE 847, Aug. 1, 1928, issue, you answered a question on cushion ports of large steam pumps. It was answered well but I believe a little more detail will help the reader to understand the action more clearly.

Ordinary duplex steam pumps have five ports as shown in Fig. 1. The two outside ones are steam ports, the next two are exhaust ports and the center one is also an exhaust port. If the piston is traveling as shown, steam is forced out through the exhaust port under the D valve and through the central exhaust port until the edge of the piston completely covers the exhaust port in the cylinder; this condition is shown in Fig. 1; therefore, the steam trapped behind the piston is compressed and acts as a cushion just as it does in a steam engine.

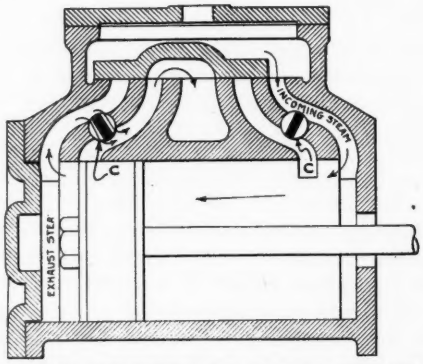


FIG. 1. STEAM CYLINDER OF PUMP SUPPLIED WITH CUSHION VALVES TO REGULATE AMOUNT OF CUSHIONING

On pumps of 12-in. stroke and larger, the cushioning effect is too great because the distance between the striking points and normal stroke is made greater the longer the stroke. In order to regulate the cushioning effect and have the pump operate smoothly, it is necessary to reduce the cushioning pressure somewhat and this is done by means of a bypass between the exhaust and steam ports as shown in Fig. 2.

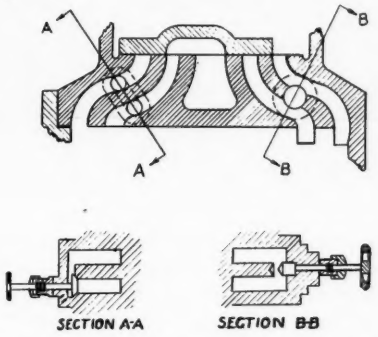


FIG. 2. TWO DIFFERENT TYPES OF CUSHION VALVES AS APPLIED TO STEAM PUMPS

Two forms are shown, the first being much like a regular valve while the second simply uses the partition between the ports as a seat. The first is generally preferred because it is easier to grind in and keep tight.

St. Petersburg, Fla. PAUL F. ROGERS.

Overcoming Flanged Pipe Difficulties

SHORTENING A PIECE of flanged, cast-iron pipe was done by cutting off the required length in a large metal-working lathe. The cut-end was then threaded in the lathe and screwed into the flange which, after having been cut from the discarded pipe, was also threaded in the lathe. The screwing-on was done in the lathe after the threads had been liberally "doped" with a mixture of litharge and glycerine.

When it is found necessary to bolt drilled flanges together and the holes can not be made to match with each other, rather than weaken the flanges by drilling more holes in them, a flange about an inch thick may be interposed between the two old flanges, the three flanges being temporarily fastened together with a couple of clamps. Then, three chisel marks are made, near each other, across the edge of the three flanges. Two of the marks are made a half-inch or so from each other and the third mark is placed a little farther away from the other marks. This arrangement of marks enables the flanges to be reassembled without trouble after being drilled.

A cork is then procured, which will slide easily but snugly in the flange-holes. One end of the cork is given a narrow cut about ⅛ in. wide across the middle of one end. The cut end of the cork is then smeared lightly with thick paint and twisted around in each of the drilled flange-holes, resulting in marking the location of each hole with paint and forming a small blank circle, in the center of which a center-punch mark is made. Corresponding holes are then drilled and tapped in each side of the thick flange. Cap-screws are then used to fasten the old flanges to the center flange.

Indianapolis, Ind. JAMES F. HOBART.

Leak Prevention in High-Pressure Piping

ON PAGE 1055, Oct. 1, 1928 issue, Jack Boston gives some instruction regarding calking steam pipes with tin foil, wire solder or lead. My experience has been that none of these will prevent a steam leak in a high-pressure steam pipe of at least 6 in. diameter and under a steam pressure of at least 200 lb. The difference of expansion and contraction between the soft metals and iron is so much that no permanently tight joint can be expected where these two materials are used as indicated.

Soft copper wire and very soft iron wire are far preferable as joint fillers to soft metals. Pipe joints of 2 in. or under can be calked adequately by a careful man if proper tools are used, without the use of a filler, unless the pipe is badly corroded, in which case it should be replaced with a new pipe.

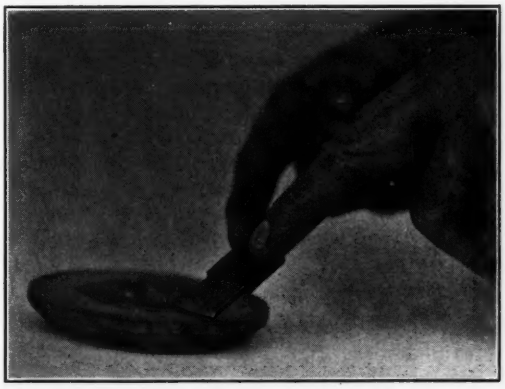
When a large, high-pressure steam pipe joint leaks and the pipe cannot be taken apart, it may prove more satisfactory to apply commercial iron-cement held in place by a properly constructed band holder, especially if the thread on the pipe or end of the fitting is defective.

Where pipes are entered into malleable iron or soft steel fittings, the chances are much more in favor of calking than where the fitting is of ordinary cast iron.

Toronto, Canada. JAMES E. NOBLE.

Tape Makes Scraper Easier to Handle

USE OF the ordinary 10 or 12-in. homemade spotting scraper becomes tiresome for the fingers when continued for a considerable length of time. Four or five turns of electrician's adhesive tape wrapped around the scraper provides a neat and satisfying grip and contact for the fingers with the end of the tool as shown. The fingers do not cramp and tire, and much more and closer work can be done when the scraper is so provided.



TAPE WRAPPED AROUND SCRAPER PROVIDES EASE OF HANDLING

Missouri Valley, Iowa. FRANK W. BENTLEY, JR.

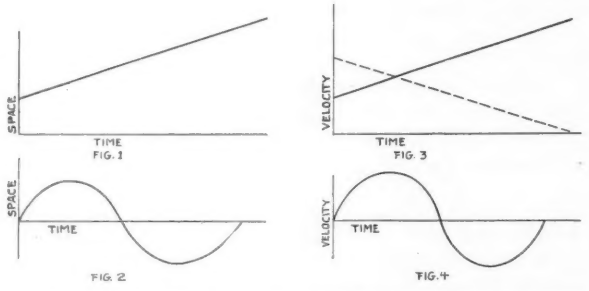
IN ALL NATURAL or raw waters, there are considerable oxygen and free carbonic acid both of which promote corrosion. Carbonic acid is best removed by chemical treatment and oxygen by mechanical means as with a deaerator.

Questions and Answers

Velocity and Acceleration

PLEASE EXPLAIN TO ME what is meant by: 6 ft. per sec. per sec. Say an elevator starts at the rate of 6 ft. per sec. per sec. and assume, also, that it is a 300 ft. per min. elevator, how is it that it will only travel about 30 ft. in 4.5 sec.? W. J. S.

A. Velocity or rate of speed is expressed in terms of —— ft. per sec.; acceleration or retardation in terms of —— ft. per sec. per sec. The latter merely means



FIGS. 1-4. SHOWING CHANGE IN SPACE, ACCELERATION AND VELOCITY WITH RESPECT TO TIME

that for uniform acceleration the increase in velocity each second is —— ft. per sec.

The relation between velocity and acceleration is shown in the accompanying graphs, in which Fig. 1 represents constant speed or uniform velocity which, therefore, is represented by a straight line at an angle with the horizontal axis as shown. Figure 2 represents a variable velocity which, during the time shown, not only changes in amount or rate of speed but also in direction since the line is a curve and extends below the horizontal axis.

Acceleration is represented by Figs. 3 and 4, in which velocity is plotted in the vertical axis instead of space as plotted in Figs. 1 and 2. Hence the full line in Fig. 3 represents uniform acceleration and the dotted line uniform retardation and the curved line in Fig 4, represents variable acceleration and retardation since it first rises and then drops.

Space traversed in a unit of time by a body having a uniform acceleration may be calculated by the formula $S = \frac{1}{2} a t^2$ where S is the distance passed over in feet, a is the acceleration in ft. per sec. per sec. and t is the time in seconds. If, therefore, the elevator starts from rest and its acceleration is constant at 6 ft. per sec. per sec., in 4½ sec. it will pass over a distance $S = \frac{1}{2} \times 6 \times 4.5^2 = 60.75$ ft. In the same manner, the space traversed for other lengths of time may be calculated and the differences between the distances for succeeding units of time will give the distance passed over in a particular unit of time. In this way, the following table has been constructed.

End of second	Entire space traversed in feet	Space traversed this second in feet	Difference
1st	3	3	..
2nd	12	9	6
3rd	27	15	6
4th	48	21	6
4½	60.75	12.75	..

It will be noticed that there is a constant difference of 6 ft. between the space traversed during succeeding seconds and that this is the acceleration rate. In the first second, since the elevator starts from rest, the distance passed over will only be one-half of the acceleration.

If the acceleration is not uniform, the amount of space traversed will be proportional to the acceleration. If the elevator is one rated at 300 ft. per min., this merely means that sufficient power is available to move it at a rate of 300 ft. per min. The time required to attain this speed of 300 ft. per min. is not specified.

Steam Costs and Steam Charges

WE HAVE A HIGH-PRESSURE heating plant consisting of a brick and concrete building costing about $20,000 and three boilers with equipment costing about $25,000. What per cent of the total cost is generally figured as yearly interest and depreciation charges? Also what is the least expensive method of finding the value of steam furnished to each of three buildings? H. E. B.

A. Replying to the first question, it is our experience that six per cent is a good average figure to allow for interest on equipment of this type, although small industrial plants may have to pay as high as seven or eight per cent. This rate, of course, is determined almost entirely by the prevailing charge for borrowing money.

The question of depreciation is by no means a simple one and cannot be answered adequately in a few words. Water-tube boilers may last for 20 to 40 yr. Pumps may have a useful life of 25 yr., heaters 20 yr., and so on, depending to some extent on the original construction and on the care with which they are maintained. A figure of 10 per cent per yr. for depreciation is often allowed for boilers but the difference between good and bad feedwater, if proper precautions are not taken to treat it, might vary this 10 per cent from 4 to 20 per cent. For a well-maintained plant, the allowance might

be only about one-half as much for depreciation as for one poorly maintained. On the whole, it is customary to use six per cent as an allowance for renewals at the end of the life of the equipment.

Besides interest and depreciation, you will have insurance and taxes, which may run up as high as five per cent on the original investment so that your total fixed charges may be from 15 to 17 per cent of the investment. These figures are about 20 per cent higher than the allowances ordinarily made for fixed charges before the War.

In addition to the item of depreciation mentioned above, a good deal of attention is now being paid to the factor of obsolescence which is almost impossible to calculate. Obsolescence means the decrease in value of a certain piece of equipment at some period before the end of its useful life, on account of the introduction of an improved type of equipment which will perform the work better or will perform the same work at a lower cost. To find the value of steam furnished for any purpose, you must take into account the fixed charged on the equipment making the steam, together with the operating charges. The factors involved in the fixed charges have just been enumerated.

Operating costs consist of cost of fuel, cost of water, oil, waste or any other supplies used in the process of making steam, either for normal operation or for repairs; cost of supervision and labor, either for normal operation or for repairs and any other items of expense that may be incurred in operating the plant. These operating costs, in the case of a plant making steam only, are most conveniently expressed in cost per thousand pounds of steam. In order to find these costs, you must have means of measuring the amounts of coal and water used and of keeping track of all other supplies and all other expenditures in the operation of the plant. If you have some means of measuring or weighing the coal that you use and the water that you put into the boilers, then you can figure your total cost for 1000 lb. of steam.

Now, if this steam is distributed to three buildings, the problem is a little more complicated, when you wish to find the value of steam furnished to each building. This amount may be measured by flow meters of various types, or, if all the condensate from your heating systems is returned to the boiler house, if the condensate is brought back to return traps which feed it to the boilers, it may be more convenient to measure the condensate with some form of water meter. These traps, if they are of the proper type, can be calibrated to act as water meters since they discharge a definite amount each time.

It is extremely difficult to tell which of these methods would prove most helpful. If you already have return traps on your condensate lines, the cheapest method might be simply to equip them with counters. If you must install some sort of meters, however, we would have to know all the details of your plant before we could tell whether or not it would be better to use the water meter on the condensate lines or steam flow meters on the outgoing steam lines.

During the past 2 or 3 yr., several types of steam flow meters have been placed on the market which are comparatively inexpensive and would be sufficiently accurate for your work.

Is Banking Fires Harmful?

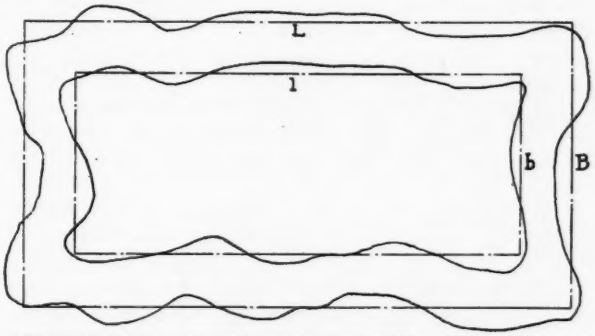
DOES ANY BAD effect on boilers or steam mains result from banking the boilers and letting the steam pressure drop every night? T. B. B.

A. To bank boilers and let steam pressure down over night has no effect on boilers or steam mains themselves, except to cause expansion and contraction, which are usually allowed for in a properly designed boiler setting and in properly designed steam lines. Some steam will undoubtedly leak into the lines from the boiler during the night and will condense there, making it necessary to provide proper drainage for the lines and to exercise care in heating them in the morning.

Coal Storage Pile Computation

COMPUTATION of the amount of coal contained in an irregular storage pile is a task with which I am confronted and I have no definite idea of how to attack the problem. I would appreciate it if you would give me the necessary method to be used for making such a computation. M. D. B.

A. You will appreciate, of course, that for irregular storage piles, the best that can be done is an approximation, which may be rather crude. The method of making such an estimate, however, would be as follows: Assuming that the pile is solid and shaped as shown



APPROXIMATE GEOMETRICAL CONTOURS ARE USED TO SIMPLIFY COAL STORAGE COMPUTATION

in the illustration, by the irregular contour lines of the top and bottom surfaces, such a plan view should be sketched as accurately as possible from the dimensions of the pile and rectangles drawn which will be as nearly as possible of the same area as the irregular figures.

It is assumed that the pile has been formed by dumping, so that there will be a reasonably regular slope at the sides of the pile. The average horizontal area would then be the mean between that shown for the bottom surface and that shown for the top, or it would be

$$[L \times B + l \times b] \div 2$$

Volume would then be mean area times height.

In case the pile runs up to a sharp point, the mean area would be the bottom area divided by two.

$$L \times B \div 2$$

Data in regard to the volume of a ton of coal vary a good deal, but approximate figures will be, for run-of-mine anthracite, 34 to 35 cu. ft. per ton of 2000 lb.; for sized anthracite, 31 to 32 cu. ft. per ton and for bituminous run-of-mine, it will vary with the quality of coal, but may be taken at 40 to 42 cu. ft. per ton of 2000 lb. as an average.

Editorial Comment

Inventory of Resources Leads to Corrective Measures

Iowa has long ranked high as an agricultural state and due to this prominence its industrial status has been overshadowed. On assuming his duties at the State University three years ago, Dean C. C. Williams, recognizing the state's many inherent power and industrial advantages, called together the power men of the state in order to take an inventory of the power and later the industrial resources of the state. A brief account of the proceedings of the third annual conference, insofar as it concerns the power plant operator, is published in another section of this issue.

In making up the inventory of resources and possibilities of industrial development, some poor and limiting conditions were obviously brought to light. Analysis of such conditions has led to corrective measures to overcome the limitations.

Iowa coal, as indicated by Professor Woodward from tests made by several members of the engineering faculty, was found to be satisfactory for domestic use. Difficulty has been experienced in using this coal in power plants principally because of its high ash content. On this account, chain grate stokers appear to satisfy the condition best hence they are widely used for this coal.

In Professor H. L. Olin's Progress Report on Research on Use of Iowa Coal, he reported results of investigations developed in the chemical engineering laboratories that give great promise of improving Iowa coal for power plant use. Among his determinations was the advantage of mixing the coal with a complementary coal, i.e., one having characteristics which neutralized detrimental effects in the Iowa coal. The university is preparing to run actual operating tests under conditions evolved from Professor Olin's experiments and much benefit is expected to result.

While Iowa's water supply has always been good, interest was shown in the paper by Professor W. H. Norton of Cornell College on Ground Water Supplies in Iowa which disclosed facts that showed not only the superior quality of the water from Iowa's deep wells but also the basis for prediction as to quality.

Much interest was also displayed in Professor Edward Bartow's paper on Influence of Quality of Water on Industry, which emphasized the advisability of testing of all water supplies and of treatment, wherever necessary, based upon individual tests and indicating methods of treatment best adapted for various waters. It is expected that both papers by Professors Olin and Bartow will be abstracted in later issues of this magazine.

So successful have this and its predecessor conferences been, not only in appraising the industrial advantages of the state but more especially in creating the establishment of corrective measures and so lively has been the interest manifested by the large number who attended, that it would seem obvious that power men in other states will see the advantage to be gained by adopting Dean Williams' method of creating interest in industrial development and expansion of power and set up an inventory of industrial resources and evalute them.

Unemployment and Surplus Man Power

In an editorial in the August 15, 1928 issue of Power Plant Engineering, attention was called to the need and desirability of definite data to controvert or substantiate the reports that there was widespread unemployment throughout the United States last year. This condition is still reported to exist. Only a few days ago, a specialist in industrial relations stated that at present there are approximately 4,500,000 unemployed persons in this country.

If one questions employers of labor, he finds a general inclination to scoff at any idea of widespread lack of work for those who are willing to work. On being pressed for facts, however, employers seldom have them but seem to take the attitude that since the country is extremely prosperous, with great construction activity, increasing bank deposits and so on, it is inconceivable that there can be much unemployment.

On the other hand, if one makes inquiry among those who have nothing to sell but their labor, he gets the impression that there is a good deal of unemployment, that it is getting harder and harder for even a skilled tradesman to find a job and that, as for the unskilled laborer—for instance, the lumber handler, the yard laborer, the "hunky"—if he once loses a job it is a real struggle to find another.

The theory has been advanced that despite the prosperity of the country as a whole, there is considerable unemployment and that its cause is a displacement of labor in all industries by the introduction of labor-saving machinery and especially of automatic machinery. The latter requires not the attendance of a comparatively large number of unskilled workers but the supervision of a few highly skilled adjusters and technicians. At the same time, production of goods of a given quality is increased by these machines.

Lest someone says that this theory is so much thin air, we refer to the recent comments on this subject of no less a man than Thomas A. Edison. In his own factories, he says, a great deal of automatic machinery is used, requiring only a comparatively few skilled mechanics to adjust and maintain it. He looks forward to the time when all industries will have developed automatic equipment to suit their needs and confesses that he is somewhat puzzled by the conditions that will be created. Possibly, by such means, the total production of the country can be greatly increased, with such a

small amount of labor that only one member of a family will be able to find work, in which case that member will have to earn enough to support the family.

Contrary to what many people believe, civilization is not being enslaved by the machine in the sense that the machine will continue to demand more labor. Rather the whole tendency is for it to demand less, as every engineer knows when he compares for example the type of skilled chemist-accountant who now operates his boilers with the 15 coal shovelers that this one man replaces. Machines in and of themselves are not dangerous to civilization, provided man has the intelligence to control the consumption of their products and to provide for the increased leisure time of those who will not be needed to operate the machines.

Possibly we are driving towards a condition in which people will have to get along with less money and more leisure time, although for many people that would be tragedy. At any rate, if we speed up production and lower its cost with automatic machinery, using fewer people for producing, then what of consumption?

It is an interesting speculation and an important one for the engineer. It means that since he is responsible for so much of the applied science that has brought us thus far on the rough road of human progress, he will of necessity be called on for guidance as we go farther on that road. As a matter of fact, he would go faster along the road that leads us away from machine enslavement were it not for the stubborn fact that as he displaces human labor with his automatic hydroelectric plants, automatic machine tools, automatic filling and packing machines, automatic conveyors and so on, in every industry, there may be no place left for the labor to be utilized.

We do not attempt to say that complete displacement of labor by machinery is at present a fact. But there is certainly a tendency in that direction, as every engineer knows. If the tendency develops into really rapid movement, will it be necessary to educate all laborers into skilled specialists with three days of work a week, sufficient wages to absorb the increased products of industry and sufficient time to consume them? In such a development, what will be the effect on women who have been employed, in increasing numbers, in industry and the professions for the past 40 yr.? We venture no prophecies on these points but present indications are that in the near future society will have to face squarely the problem of surplus man power.

The Farmer from Missouri

Reports from many sections of the country on the status of rural electrification indicate that the farmer is sold on the value and comfort of electricity but he still has to be shown that the cost of electricity can be brought within the limits of the farm pocketbook.

As with other industries, assuming that modern machine farming is an industry, the value of electrification depends upon the use made of it. The consensus of opinion is that the farmer who uses only about 300 kw-hr. a year is usually dissatisfied. When his consumption reaches 1000 kw-hr., he is satisfied and when it is built up to 3000 kw-hr. he is enthusiastic, his enthusiasm mounting rapidly as his load keeps increasing.

For the 300 kw-hr. farmer, electricity is largely a matter of comfort, used only for lighting, probably rather inadequate lighting, at that, for which he is paying a high charge. As its use is extended, the unit cost decreases and instead of being a luxury it begins to prove an excellent business investment.

Rural electric service departments, as maintained by many companies, have been a big factor in increasing the average consumption. In one company, the service department increased the average monthly consumption of some 500 farms wired prior to 1926 from 28 to 44 kw-hr. while several hundred new customers added in the past three years, each one of which has been under the guidance of the department, averages 150 kw-hr. a month.

Cost of the current is, however, not the major item in the well and adequately electrified farm. It is estimated the overhead on a farmer's investment in equipment is two and a half times his bill for current.

Not only does electricity pay for itself but it has a broadening effect on the community, allowing more leisure, encouraging better business conditions and practices. The problem of the rural power salesman has apparently narrowed down to a point where it is necessary not to sell electricity but to find legitimate applications which will give the farmer sufficient load to make electrification a business proposition which the farmer cannot miss and not a luxury which he feels he should not afford.

Storms and Interconnection

Advantages of interconnection of electric power lines in meeting emergency conditions caused by storm and flood conditions are demonstrated from time to time by severe emergency tests brought about by abnormal conditions.

While this is being written Northern Michigan is just recovering from a terrific sleet storm which carried down many of the power lines feeding the Consumers Power Co. system from the hydroelectric plants on the northern rivers.

Reserve steam capacity was put into immediate service while the interconnection with the Detroit Edison system automatically fed into the Consumers system. At one time the load on this interconnecting line reached approximately 35,000 kw.

Perhaps Providence arranged the sleet storms to enable the Detroit Edison Co. to pay a favor of several weeks ago when fog and smoke conditions turned day into night in Detroit, thus superimposing the usual evening lighting load on the daytime industrial load. To carry this extraordinary peak load, the Detroit Edison called upon the reserve of the Consumers Power Co. through the same interconnected line.

On a strictly engineering or economic operating basis, it may be difficult to justify interconnection but as an emergency measure the value of these interconnected systems is being proven every day.

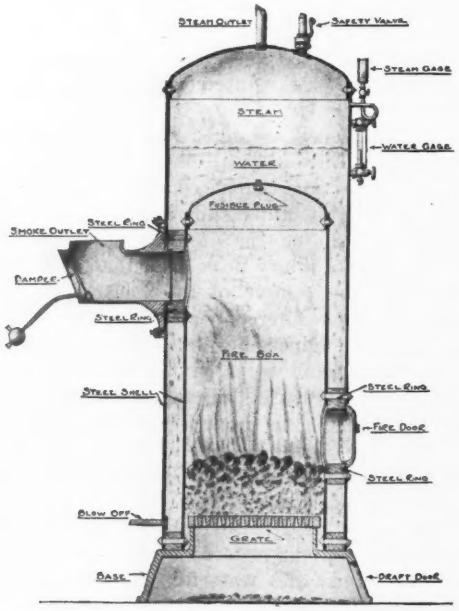
"MAN'S CHIEF BUSINESS," says Slosson, "is in reversing the processes of nature." He undoes iron rust to get the iron out. He releases energy from coal that ancient plants so patiently stored away. He takes motion from the winds and waterfalls and freezes it in storage batteries for later use.—Baker Brownell.

Power Plant Engineering Developments and News

Tubeless Boiler for Small Installations

FOR VARIOUS small applications such as making steam in small dairies, the vertical tubeless boiler shown here has recently been placed on the market by Orr & Sembower, Inc., Reading, Pa. In certain sections of the country, water conditions cause chemical action that may destroy the metal in boiler tubes. This trouble may often cause greater expense than the additional cost of fuel per horsepower. For this reason, the tubeless boiler was produced, although in determining the size boiler of this type to use on the job, it is necessary to remember that it will produce only about 70 per cent of its rated horsepower when steady operation is required.

Steel plate used in these boilers is firebox quality, containing a sufficient quantity of copper to insure minimum corrosion and manufactured to have a 155,000-lb. tensile strength per square inch in accordance with A. S. M. E. and all other boiler code specifications, including the Massachusetts standard. Special attention is called to the electric steel mud ring, door frame and smoke outlet frame. These boilers are designed for a safe working pressure of 100 lb. and are required to stand a test of 160 lb. minimum hydrostatic pressure.



CROSS-SECTION OF VERTICAL TUBELESS BOILER

A fusible plug is screwed into the center of the furnace head according to standard practice.

Standard equipment furnished consists of: base, grate, hood, steam gage, glass water gage, gage cocks, pop safety valve, blowoff valve, check and stop cock, fire door, hand hold plates and yokes and smoke outlet with damper. Injector and stack can also be furnished.

These boilers are made in sizes from 24 in. diameter to 3 in. high, with water capacity (at low water line) of 31 gal., to 36 in. diameter, 105¼ in. high, with capacity of 135 gal.

Automatic Electric Soot Blowers

DESIGNED to make possible the automatic electrical operation of soot blowers, a system of motor-driven blower units with suitable automatic controls, as shown in the accompanying illustrations, has recently been placed on the market. It is designed to give positive operation of each blower element in proper sequence at the proper speed and number of revolutions of the

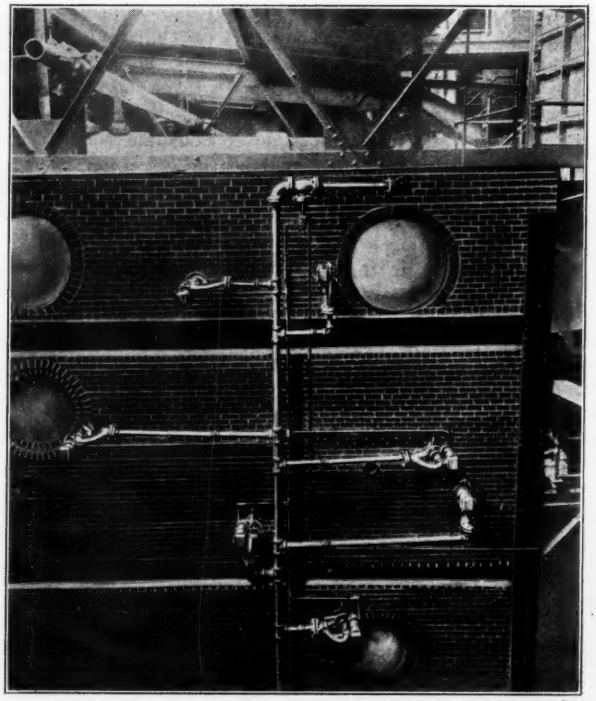
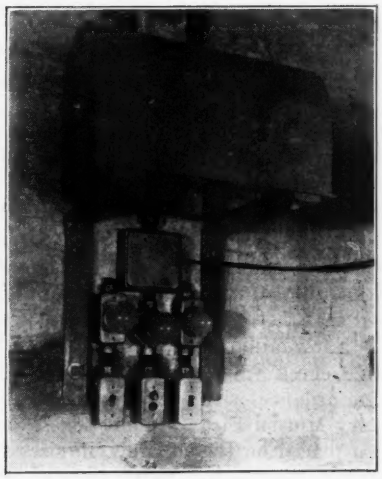
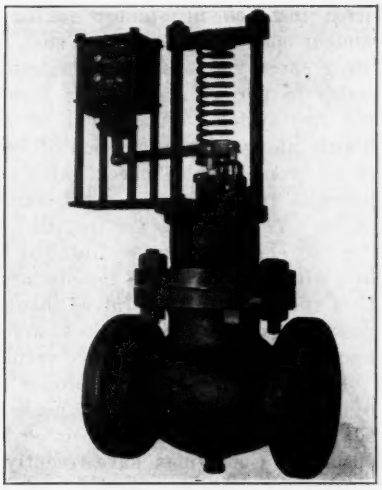


FIG. 1. AUTOMATIC ELECTRIC SOOT BLOWERS AS INSTALLED ON A BOILER





FIGS. 2-4. DETAILS OF EQUIPMENT USED IN AUTOMATIC ELECTRIC SOOT BLOWER SYSTEM

Fig. 2. Soot blower unit driven through planetary transmission by electric motor. Fig. 3. Controls for system, showing indicating lights for each of 3 boilers, starting buttons and case containing circuit breakers, delayed action switch and other automatic switching devices. Fig. 4. Electrically-operated master valve for controlling steam supply to soot blowers

element for effective cleaning and to eliminate the human element of the operator, who may tend to slight units that are hard to turn and who usually operates each element at a different speed. Furthermore, where frequent blowing is necessary, the amount of time used in blowing by the operator may amount to two or three hours out of the 24 hr.; as the system is designed to operate without further attention after the starting button is pressed, the time thus saved may be utilized by the operator in more profitable ways.

This system, Fig. 1, consists of a motor drive unit attached to the standard Diamond hand-operated valv-in-head unit, an electrically-operated master valve, an electrically-operated drain valve and a control panel. This motor drive unit is so constructed that it can be installed on any existing hand-operated, valv-in-head unit, by removing the sheave wheel of the latter.

Motor drive unit, Fig. 2, consists of a 1/6-hp., 1800-r.p.m. motor, a reduction transmission of the planetary creeping tooth combination giving a total reduction of 3600 to 1 and an automatic switch. The electrically-operated master valve, Fig. 4, is a solenoid-controlled globe valve, actuated through the medium of a piston attached to the valve stem and a relay valve admitting or releasing steam in a cylinder above the piston. The solenoid is lever-connected to the relay valve. Drain valve is a ¾-in. globe valve, the stem of which is directly connected to the armature of a solenoid.

Control panel, Fig. 3, consists of an overloaded, inverse-time-limit circuit breaker with no voltage release, a delayed-action secondary automatic connecting switch and an indicating light, the burning of which indicates the operation of the soot blowers on any individual boiler.

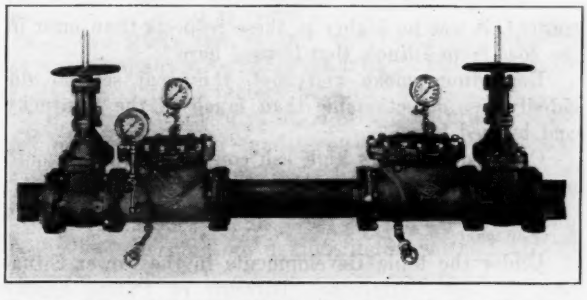
To blow a certain boiler, the operator merely throws the switch in the control panel. This puts the system into operation, the blowing cycle is carried out and the system shuts down without further attention.

When the switch is thrown, the indicating light on the panel becomes bright and the master valve opens to admit steam to the soot blower lines. The drain valve being open, the blower lines are given ample time to heat up and drain of all condensate, the time interval for this being about three minutes. At the end of this time, the delayed-action connecting switch in the control panel cuts in the motor on the first or "A" unit. Electrifying of this motor circuit simultaneously closes the drain valve and holds it closed as long as the motor circuit is energized. The "A" unit revolves at the exact speed and number of revolutions predetermined when it is installed and at the completion of this cycle, the automatic switching devices cut out the "A" unit motor and cut in the "B" unit and so on until all blower units have been operated. When the last unit completes its operation, it throws the circuit breaker when the indicating light goes out, the master valve closes, the drain valve opens and the blowing cycle is completed.

This automatic soot blower system is a product of Diamond Power Specialty Corp., Detroit, Mich.

Valves for Fire Protection Systems

INDUSTRIAL PLANTS often utilize available public water systems as the primary supply for automatic sprinklers and other fire protection equipment. To provide a secondary supply of large capacity, they have



DOUBLE CHECK VALVE EQUIPMENT WITH SPACER FOR CROSS-CONNECTIONS BETWEEN FIRE SERVICE AND PUBLIC MAINS

often installed fire pumps taking suction from convenient open bodies of water, such as rivers and ponds, using check valves on the connections from the public mains to permit maintaining high pump pressure in the fire system. A method of safeguarding public health, along with prevention of loss by fire, is the use of all-bronze double check valve equipment as shown herewith for fire service cross connections from public mains. These valves are installed in series; generally the two check valves are installed between gate valves in a pit, where they are readily accessible for examination and test. Check valves should be equipped with pressure gages and rest cocks so arranged that the tightness of each check valve can be verified in a few minutes.

Jenkins FM special all-bronze double check valves of the latest improved type made in accordance with the specifications of the Associated Factory Mutual Fire Insurance Companies, have recently been placed on the market for the above service. In designing, the manufacturer has coöperated closely with Factory Mutual engineers. The disc-holder is fitted with a special rubber facing or disc to facilitate absolute tightness.

These valves may be bolted together, thus providing a space of 18 in. between clappers which is considered sufficient to prevent any ordinary material found in a pipe from holding both clappers open at the same time. To improve the efficiency still further, a piece of pipe or a spacer from three to five feet long, installed between the checks, is advised as shown in the illustration. Complete equipment for Jenkins FM special all-bronze double check valve installations can be furnished, including indicator posts, extension spindles and bronze trimmings complete, consisting of gages, valves for testing and draining, cocks, fittings and nipples.

Valves shown above, made by Jenkins Bros., 80 White St., New York, are supplied in bronze for pressures up to 250 lb. For 150 lb. water pressure, a line of iron body gates is also supplied, with bronze-bushed stuffing-boxes, bronze stuffing-box nuts and bronze glands, in sizes from 2 to 24 in. and with stationary or rising spindles or hub ends. Globe, angle, cross, check and valves are supplied entirely of bronze in sizes up to 3 in. for other requirements on fire protection systems and for various pressures up to 250 lb.

Iowa Power and Industrial Conference

HELD AT THE UNIVERSITY OF IOWA, IOWA CITY, APRIL 2 TO 4, 1929, UNDER THE SPONSORSHIP OF THE COLLEGES OF ENGINEERING AND OF COMMERCE WITH THE EXTENSION DIVISION COÖPERATING

PRESIDING at the opening session, Dean C. C. Williams pointed out that because of its geographical position and of the character of its natural resources, Iowa is destined to have a notable industrial development within the next quarter century. Few states are more fortunate than Iowa in availability of power and few have equal wealth per capita. Much rests in the desire on the part of power companies to promote industrial loads.

IOWA COAL TESTED FOR DOMESTIC USE

In his paper on Observations on a Car of Iowa Coal, Professor Sherman M. Woodward stated that soon after the close of the 1928 Power Conference a 40-t. car load of Iowa coal was received and distributed among members of the engineering faculty for the purpose of testing its suitability for domestic use. The following statements represent the consensus of opinion of those who tried the coal:

There was no difficulty about burning the coal in the ordinary house furnace.

Although the coal seemed high in ash and water content, it was no higher in these respects than most of the coal from Illinois that is used here.

Regarding smoke and soot, this coal seemed decidedly less objectionable than much of the Kentucky coal burned here.

On account of its high ash content, the coal would not hold a fire well and a low fire would go out easily.

This coal seemed more friable than coal coming from farther east.

Under the topic Developments in the Power Situation, by Joe Carmichael, Director of Public Utility Information, Des Moines, the rapid extension of transmission lines, especially in connecting and interconnecting towns and cities was indicated. Only 24 towns in Iowa, out of a total of 922, do not have electrical service. Iowa maintains its position as being probably the most completely electrified state in the country so far as its cities and towns are concerned, 99.7 per cent of the residents of the state have electric service available to them and 13 per cent of the farms are electrified. Millions of dollars have been spent in 1928 in extending and improving electric facilities.

His summary of the report of the U. S. Census of the Electrical Industry indicated that the trend was towards larger and fewer power stations and that there was a decrease of 27 per cent in the number of municipal plants.

POWER UTILIZATION IN IOWA INDUSTRIES

The afternoon session was presided over by Professor S. L. Miller, Director of Business Research. W. H. Norton, Professor of Geology, Cornell College, presented a paper on Ground Water Supplies in Iowa in which he pointed out the excellent quality of Iowa's deep wells, indicating its superiority over river waters.

Edward Bartow, Head, Department of Chemistry, discussed Influence of Quality of Water on Industry emphasizing the advisability of treating boiler waters. Any water containing more than 10 grams of hardness per gallon should be treated, he asserted. With respect to scale formation, the zeolite process gives perfect results. Electro-osmose, a recently developed treatment method also gives zero hardness water at a cost much cheaper than by distillation. Lime and lime-soda methods do not change the amount of substance in solution. Zeolite treatment increases the tendency to foam. Use of combination treatment methods was advocated.

Availability of Electric Power for Industrial Development by L. R. King, Assistant General Manager, United Light & Power Co., Davenport, was the last paper of this session. While, in 1899, the average worker in the United States was directing 2.14 hp., in 1928, he directed 4.7 hp. This compares almost exactly with that of the power directed by the average Iowa factory employe. Central stations are serving 66 per cent of motorized equipment. In this, Iowa leads the country as a whole.

Curves were presented which showed the increase in motive power installed in Iowan industries. With the network of transmission lines extending over the state, Mr. King asserts that no longer does the operator have to locate his enterprise at a power source.

Purchase of Electric Power Advocated

In advocating the purchase of electric power, Mr. King stated that by this means enormous sums of money are released to operators, which, he says, can be turned over more frequently than if invested by these operators in power equipment. Mass production applied to utilities has enabled them to keep their production costs on a downward trend resulting in benefit to the people by lower costs for electric service.

Recognition of the desirability of industrial location in Iowa for many types of industries is shown by the fact that of 10,240 new central station customers added in Iowa in 1928, 28.3 per cent are classified as power and miscellaneous. This figure is comparable to 5.35 per cent for the whole United States and shows that the percentage of power customers added in Iowa in 1928 was 5.3 times that for the United States as a whole.

Power as a Factor in Production

Wednesday morning's session was opened by Professor J. T. Rood, presiding. Relation of Power Utilization to Production was the theme of the first paper by Arthur Huntington from whose analysis it was shown that the income per worker in any nation is vitally influenced by the amount of power available to him and that even in the various states of this country, agriculture is generally prosperous in proportion to the power available. Showing the effect of efficient use of power, Mr. Huntington stated that America's highly paid wage earners are the lowest paid workers on earth. A Russian railroad engine driver receiving from $30 to $36 per yr. receives nearly three times as much per ton mile as our highest paid American railroad engineers. America uses more power and produces more products than other countries and this increased output is out of proportion to the increased power used. Mr. Huntington also showed that when, after the war, European nations tried to copy American machinery, it cost them much more to build than it did in our country even with our higher labor costs.

Production Increased by Proper Lighting Effects

A. D. Altree, District Illuminating Engineer, Edison Lamp Works, Chicago, in his paper on Plant Illumination a Factor in Production, emphasized that lighting should be considered as to effect upon the working plane and hence that judicious use of proper reflectors should be made, also that glare and other fatiguing effects of improper lighting should be avoided. Increase of from 8.5 to 35 per cent in product can often be obtained, he declared, by better lighting. Advantage of keeping lighting fixtures clean was brought out in the terse statement, "Water is cheaper than watts."

Professor Edward Barlow presided at the afternoon session which was opened by Professor J. T. Rood with a paper on Industries in which Electric Power is Adapted, and this was followed by Industrial Loads, Present and Future in Iowa, by R. D. Hayes, Power Engineer, Interstate Power Co., Dubuque. Speaking of possible industrial expansion, Mr. Hayes showed that Iowa has remarkable industrial facilities such as excellent railway transportation, reasonable labor cost, nearness to raw materials, good water, together with the possibilities of excellent river transportation.

Electric Heating Evens Load Curve

Industrial electric heat offers great possibilities for future loads. Among those applications now in prominent use in Iowa are: brass melting and other electric furnaces, electric heat treating furnaces, continuous electric enameling furnaces and other applications, especially that of water heating.

In his development of his topic, Industrial Development and the Public Utilities, G. C. Heisterman, Industrial Development Engineer, Public Service Company of Northern Illinois, classified his subject as follows:

I. Qualifications of Public Utilities to Deal with Industrial Development Problems.

II. The Industrial Development Department and Its Activities.

III. A Community Program and Industrial Survey.

IV. Economic Factors Entering Into Plant Location.

V. Industrial Trends and Possibilities.

Development Service Offered by Utilities

In illustrating how well the Industrial Development Department is organized, Mr. Heisterman, enumerated a number of examples showing how a public service company can take a leading part in furnishing technical assistance to help the individual community to develop itself industrially if it so wishes. He discussed the four stages of power development; the pioneering, engineering, commercial and public relations stages. Under the latter, he pointed out that the extensive customer ownership of utility stock is evidence of friendly public relations and of the intelligent understanding of the utilities problems which exist today.

Industrial Development Field Comprehensive

The duties of an utility industrial development department, he listed as follows:

A. To study the natural and industrial resources of the company's territory and be familiar with the factors involved in factory location.

B. To study the utilization of agricultural products in industry and be familiar with the raw material supply, methods of conversion, and ultimate use or consumption of such products.

C. To encourage and assist communities in formulating and carrying out definite industrial and agricultural development programs.

D. To supply manufacturers with data needed by them in deciding on the location of plants.

E. To assist in removing obstacles in the way of expansion of present industries and to stimulate the development of new industries, large and small.

F. To coöperate with the various sales departments in selling the company's service to manufacturers.

G. To maintain contact with other bodies interested in the industrial expansion of the territory and exchange with them, information of mutual interest.

H. To promote reciprocal buying between the company and industries located in its territory and among the industries themselves.

BONUS ENCOURAGES BETTER BOILER OPERATION

In his paper on Making Man-Power More Effective, Professor R. M. Barnes emphasized the setting of performance standards and of remuneration by a bonus method. Of especial interest to power plant operators was his advocacy of rewarding boiler room firemen in direct ratio to the effort exerted in maintaining proper operating conditions, using as a standard the CO_2 readings and the percentage of combustible in the ash.

News Notes

ILLINOIS STOKER CO., Alton, Ill., is now being represented in the Pittsburgh territory by Bradshaw & Co., 530 Fourth Ave., Pittsburgh, Pa.

BROWN INSTRUMENT CO., Philadelphia, Pa., announces the appointment of two vice-presidents as follows: Charles H. Kerr, vice-president and general manager; George W. Keller, vice-president and general sales manager.

GEORGIA POWER CO., Atlanta, Ga., is said to have plans maturing for the construction of a new steam-operated electric generating plant on the Chattahoochie River, near the city. The plant will be equipped with an initial steam turbine generating unit of 100,000 hp. capacity and at later dates, it is proposed to provide three additional units of this same size for a total rating of 400,000 hp. The development is reported to cost more than $5,000,000.

DWIGHT P. ROBINSON, president, United Engineers & Constructors, Inc., Philadelphia, Pa., has announced the formation of United Engineers & Constructors (Canada) Ltd., with headquarters in the Drummond Building, Montreal. R. M. Henderson is managing director of the new company.

BOILER ENGINEERING CO., Newark, N. J., announces that Fred W. Linaker, Liberty Bldg., New York City, has taken over the New York territory. Associated with Mr. Linaker is C. H. Baker, formerly mechanical engineer for the Public Service company, Newark, N. J.

UNITED STATES CIVIL SERVICE COMMISSION announces open competitive examinations for senior mechanical engineer, mechanical engineer, associate mechanical engineer, assistant mechanical engineer, chemical, associate chemical and assistant chemical engineers, applications for which must be on file with the secretary of the Fourth U. S. Civil Service District, Washington, D. C., not later than May 14. They are to fill vacancies in the Chemical Warfare Service, Edgewood Arsenal, Md. The salaries range from $4600 to $5200 a year for the senior engineers to $2600 to $3100 for the assistant engineers. Competitors will not be required to report for examination at any place, but will be rated on their education, training, experience and fitness. Full information may be obtained from the United States Civil Service Commission, Washington, D. C., or from the secretary of the Board of Examiners at the post office or customhouse in any city.

NEW YORK OFFICE of the Murray Conduit Systems is now located at 88 Lexington Ave. Prior to this, it was at 55 Duane St.

N. H. BOYNTON, in charge of sales promotion, National Lamp Works, representing Light's Golden Jubilee Committee, offers a first prize of $150 cash and a second prize of $75 cash to the two employes of member companies of the National Electric Light Association who prepare the two best essays on "Light's Golden Jubilee" in conformity with the rules and regulations of the competition. Contestants may obtain informative material on light and the development of modern lamps and lighting devices from W. M. Skiff, chairman, Speakers Bureau, Nela Park, Cleveland, Ohio. Any employe of a member company of the N. E. L. A., except officers, managers, general office department heads and those who specialize in the sale of light, is eligible. All essays should be mailed to W. M. Skiff, chairman of the Speakers Bureau, Nela Park, Cleveland, Ohio, so that they will be received by him on or before May 15. Essays are to be sent in a plain envelope, postage paid, with no identification marks on either the envelope or the essay, which is to be accompanied by a plain, sealed, blank envelope, containing a 3 by 5-in. card bearing the name and address of the contestant, the name of the company by which he or she is employed and the department with which he or she is connected. Each essay and its accompanying envelope will be marked when it is received by the judges and the essays will be read without identifying the writers, until after the award has been made, to insure unprejudiced judging of the material. Complete details regarding the competition can be obtained from W. M. Skiff, chairman of the Speakers Bureau, Nela Park, Cleveland, Ohio.

WEIL PUMP CO., 215 W. Superior St., Chicago, Ill., announces the appointment of A. C. Sigmon Engineering & Equipment Co., 216 Haywood Bldg., Asheville, N. C., as its representatives in the southeast.

COOPER-BESSEMER CORP., representing a combination of The C. & G. Cooper Co. and The Bessemer Gas Engine Co., was recently announced. E. J. Fithian, president of The Bessemer Gas Engine Co., will be chairman of the board and B. B. Williams, president of The C. & G. Cooper Co., will be president and general manager of the new corporation. The remaining officers will be chosen from the active executives of both companies. There will be practically no change in the personnel of the sales and service organizations. It will not be the policy of the combined organizations to effect any economies by reducing the sales and service forces. Rather they will be increased at some points with the idea of offering the trade still better service. This combination brings together two of the oldest manufacturers of power machinery in the country. The C. & G. Cooper Co. was established 96 yr. ago at Mt. Vernon, Ohio, by two Cooper brothers. The Bessemer Gas Engine Co. was organized at Grove City, Pa., more than 30 yr. ago.

Books and Catalogs

THE PROFESSION OF ENGINEERING, by Dugald C. Jackson and W. Paul Jones; John Wiley & Sons, New York City; 124 pages; 5 by 8 in.; cloth, 1929; price, $1.50 net.

This series of essays on the functions of an engineer, his education and the activities in various branches of the profession has been chosen with excellent discrimination and arranged to give a clear conception of what engineering is, its joys, its possibilities and its hardships. To the young man contemplating the work and to the engineering student, it will give a vision of what lies ahead. To the experienced engineer it will bring renewed appreciation of the importance and requirements of the work in which he is engaged and to the layman, it will bring a better conception of what the engineer does for the world and humanity.

The soundness and authority of the discussion is evident not only from the names of the editors of the essays but from those of the writers, Professors Daniel W. Mead and George F. Swain and Messrs. George H. Barrus, Robert Peele, Harold W. Buck, John H. Hammond and Herbert C. Hoover, all of whom have attained distinction in their chosen fields. The book is one well worth reading by engineers and passing on to friends in other lines of activity as a means of increasing their regard for the work of engineers and their value to society.

IN AN ATTRACTIVE 32-PAGE BULLETIN, the Ljungström air preheater is described in detail with many illustrations of actual installations and complete details of the equipment itself. This is bulletin No. 129, issued by the Air Preheater Corp., 25 Broadway, New York. Analysis of the economy of the air preheater is given for various conditions and many cross sections of power plants show the methods of installing it under varying boiler arrangements. Regenerative heating surface of the improved type, recently developed for the heaters, is described in detail and several operating factors are discussed, such as prevention of leakage from air to gas chamber, use of separate or integral fans, power required, removal of soot and fly ash and corrosion.

"METERING FLOW Saves Steam and Power" is the subject of a catalog recently issued by the Brown Instrument Co., Philadelphia, Pa., which illustrates the details of Brown meters and their application for various purposes in the plant.

C-E MULTIPLE RETORT Underfeed Stoker of super station type is described in a catalog received from Combustion Engineering Corp., 200 Madison Ave., New York City. Material changes in design are covered by the text and illustrations, results secured from stokers now in operation showing a distinct advance. The catalog gives a clear understanding of the construction and application of the equipment.

NOVEL SUBSTATION construction is described and illustrated in publication No. 57 of the Delta-Star Electric Co., 2400 Block, Fulton St., Chicago, Ill. Rotating combination switching buses, few insulators, steel column and girder construction are among the features.

BALDEN DUTCH OVEN FURNACE for burning waste wood fuel is described in a 4-page folder by U. S. Iron Works, Seattle, Wash.

THE NEW Curtis Pipe Cutting and Threading Machine is the title of a booklet describing the results of a half century of progress as embodied in the products of The Curtis & Curtis Co., Bridgeport, Conn. Details of construction, sizes and capacities are given.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC.

required by the Act of Congress of August 24, 1912, of Power Plant Engineering, published semi-monthly at Chicago, Ill., for April 1, 1929.

State of Illinois, } ss
County of Cook, }

Before me, a Notary in and for the State and county aforesaid, personally appeared Charles S. Clarke, who, having been duly sworn according to law, deposes and says that he is the Secretary of the Power Plant Engineering and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and address of the publisher, editor, managing editor, and business managers are:

Publisher, Technical Publishing Co., Chicago, Ill.
Editor, Arthur L. Rice, Chicago, Ill.
Managing Editor, R. E. Turner, Chicago, Ill.
Business Manager, E. R. Shaw, Chicago, Ill.

2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporaton, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.)

Technical Publishing Co., Chicago, Ill.
E. R. Shaw, Chicago, Ill.
Arthur L. Rice, Chicago, Ill.
K. L. Rice, Chicago, Ill.
Charles S. Clarke, Chicago, Ill.
W. A. Phillis, Cleveland, O.
R. E. Turner, Chicago, Ill.
A. W. Kramer, Chicago, Ill.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.)

There are none.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is..... (This information is required from daily publications only.)

CHAS. SANFORD CLARKE, Secy.

Sworn to and subscribed before me this 23rd day of March, 1929.

[Seal.] EDDIE H. KAHL.

(My commission expires March 20, 1932.)

NOTE.—This statement must be made in duplicate and both copies delivered by the publisher to the postmaster, who shall send one copy to the Third Assistant Postmaster General (Division of Classification), Washington, D. C., and retain the other in the files of the post office. The publisher must publish a copy of this statement in the second issue printed next after its filing.

Power Plant Construction News

Ala., Birmingham—The Lamson & Sessions Bolt Co., 1971 West Fifty-eighth Street, Cleveland, Ohio, will install power equipment in proposed new plant on site recently acquired at North Birmingham, entire project to cost approximately $400,000. The George S. Rider Co., Century Building, Cleveland, Ohio, is engineer.

Ala., Tarrant City—The Southern Cereal Co. plans installation of power equipment in new cereal mill unit to cost about $115,000.

Calif., Fruitvale—The United Filters Co., Hazelton, Pa., plans installation of power equipment in proposed new filter machinery manufacturing plant at Fruitvale, entire project to cost more than $250,000. A boiler plant is projected.

Del., Newport—The Delaware Wood Preserving Co., operated as an interest of the Century Wood Preserving Co., Century Building, Pittsburgh, Pa., Grant B. Shipley, president, plans installation of power equipment in connection with proposed new creosoting plant on 285-acre tract of land near Newport, entire project to cost close to $100,000.

Fla., Clewiston—The Southern Sugar Co. will install power equipment in connection with extensions and improvements in cane sugar mill reported to cost more than $250,000. William G. Ames is consulting engineer.

Ill., Rockford—The Rockford Drop Forge Co., Ninth Street, has filed plans for one-story addition to boiler plant, 60x72 ft., and will begin superstructure at once.

Ind., Hammond—The Lever Brothers Co., 146 Broadway, Cambridge, Mass., plans installation of power equipment in proposed new soap-manufacturing plant at Hammond; a boiler plant is projected. Entire project will cost more than $2,500,000.

Ind., Jasper—The New Indiana Chair Co., Jasper, M. L. Wagner, president, has authorized the construction of a steam-power house, 40 x 40 ft., in connection with a new addition to plant on Vine Street, near Thirteenth Street, entire project to cost about $100,000. Edwin C. Berendes & Associates, McCurdy Building, Evansville, are architects.

Iowa, Sumner—The City Council has approved a franchise for the Municipal Utilities Co., Liberty Building, Des Moines, Iowa, covering the construction and operation of a local electric light and power plant and it is understood that project will proceed at an early date, reported to cost in excess of $60,000.

Kans., Wichita—The Cessna Aircraft Co., Wichita, plans installation of power equipment in connection with proposed new airplane manufacturing plant reported to cost more than $100,000.

Md., Baltimore—The University of Baltimore, College Park, has plans under way for the construction of a one-story steam power plant for central heating service, reported to cost close to $200,000, with equipment. Smith & May, Calvert Building, Baltimore, are architects.

Md., Frederick—The Union Mfg. Co. plans installation of power equipment in addition to hosiery mill reported to cost more than $100,000. Lockwood Greene Engineers, Inc., 100 East Forty-second Street, New York, is engineer.

Mass., Somerville—The Boston & Maine Railroad, North Station, Boston, plans construction of power plant in connection with new locomotive house and shops at Somerville, entire project to cost more than $1,000,000.

Mich., Dowagiac—The Sterling Ice Co., has plans maturing for the construction of a new addition to its plant to cost about $50,000, and will ask bids on general contract late in May.

Minn., Faribault—Bain & Robb, 2118 Lyndale Avenue, South, Minneapolis, Minn., engineers, have been engaged by the Shaft-Pierce Shoe Co., Faribault, and a group of other mercantile concerns, operating a central steam power plant for heating service, to prepare plans for an addition to present unit, including installation of additional equipment. Project is reported to cost close to $50,000.

Minn., Warren—The Municipal Water, Light & Power Department, Victor Malm, chief engineer, is considering extensions and improvements in the municipal power plant, including installation of modern type Diesel engines to replace present equipment. Estimates of cost will soon be made.

Neb., Elgin—The Western State Utilities Co., Central City, Neb., has plans under way for construction of one-story power house at Elgin, reported to cost about $30,000. The Betts-Blumer Co., Kearney, Neb., is engineer.

N. J., Elizabeth—The Elizabethtown Water Co., 64 Broad Street, Elizabeth, will soon begin construction of a one-story pumping plant, 45 x 60 ft., at Irvington Avenue and Prince Street, reported to cost about $25,000, with equipment.

N. J., Perth Amboy—The Raritan Copper Works, Perth Amboy, has authorized a pumping plant in connection with a mill expansion and betterment program now in progress, entire project to cost more than $125,000.

N. C., Wilmington—The Wylie Cooperage Co., Wilmington, plans rebuilding of engine and boiler department, recently damaged by fire; a portion of main mill also was destroyed with total loss reported in excess of $30,000.

Ohio, Alliance—The Transue & Williams Steel Forging Corporation, Alliance, plans installation of power equipment in connection with an expansion and improvement program to cost more than $500,000.

Ohio, Toledo—The Toledo Scale Co. plans installation of power equipment in connection with proposed plant additions on 80-acre tract of land, recently acquired, entire project to cost more than $650,000.

Ohio, Youngstown—The Wehle Baking Co., Youngstown, plans installation of power equipment in proposed new baking plant to cost about $100,000. The W. E. Long Co., 155 North Clark Street, Chicago, Ill., is engineer.

Ont., Oklahoma—The Eagle-Picher Lead Co., Joplin, Mo., plans installation of power equipment in proposed new smelting plant at Ontario, entire project reported to cost about $100,000.

Ore., Salem—The Oregon-Washington Water Service Co., Salem, is considering the construction of a filtration plant for local waterworks service, estimated to cost more than $200,000.

Pa., Jermyn—The West Mountain Coal Co. plans installation of power equipment in connection with proposed rebuilding of coal breaker, recently damaged by fire, with loss reported at close to $70,000.

Texas, Dallas—The Rogers Lumber & Mfg. Co., Dallas, is said to be planning the installation of power equipment in connection with proposed rebuilding of portion of mill recently destroyed by fire, with loss reported at close to $100,000.

Texas, New Braunfels—A steam power plant is projected in connection with a proposed cotton mill to be constructed at New Braunfels, by James McDowell, City National Bank Building, San Antonio, Texas, and associates. A company, it is understood, is being organized to carry out the enterprise, which is reported to cost more than $500,000.

Utah, Salt Lake City—The City Council is said to be planning the installation of pumping machinery and auxiliary equipment in connection with proposed extensions and improvements to municipal waterworks, for which preliminary surveys are under way. It is proposed to arrange a bond issue of close to $3,000,000, for the project.

Wash., Metaline—The Pend Oreille Lead-Zinc Co., Old National Bank Building, Spokane, Wash., Lewis P. Larsen, president, plans installation of power equipment in connection with proposed electrolytic zinc plant at Metaline, entire project reported to cost more than $2,000,000.

Wash., Renton—The Cottage Lake Lumber Co. has approved plans for the immediate construction of a new electric-operated lumber mill on local site to cost about $70,000, with equipment. James C. Carlson is head.

W. Va., Bluefield—The West Virginia Water Service Co. is said to be planning the installation of pumping machinery and auxiliary equipment in connections with extensions and improvements in waterworks; filtration equipment will be installed. Entire project is reported to cost about $180,000.

Wis., Prairie du Chien—The Prairie du Chien Woolen Mill Co. has asked bids on general contract for extensions and improvements in boiler house and power plant, reported to cost about $75,000, with equipment. Charles A. Cahill & Sons, 214 Mason Street, Milwaukee, Wis., are engineers.